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ABSTRACT

Suggestions for methods of teaching the science material included in grades three and four of the elementary school curriculum of the Education Department of Victoria are illustrated by descriptions of successful teaching episodes, particularly when science activities have served as an introduction to written expression, applied number, and social studies "lessons." The emphasis throughout is on individual student manipulation and experimentation in a flexible, inter-related program. In each of the sections, "Matter," "Energy," and "Life," methods of assisting the development of observation, categorization, measurement, organization, inference, testing ideas, and language skills are suggested. (See also SE 012 719 and SE 012 721.) (AL)

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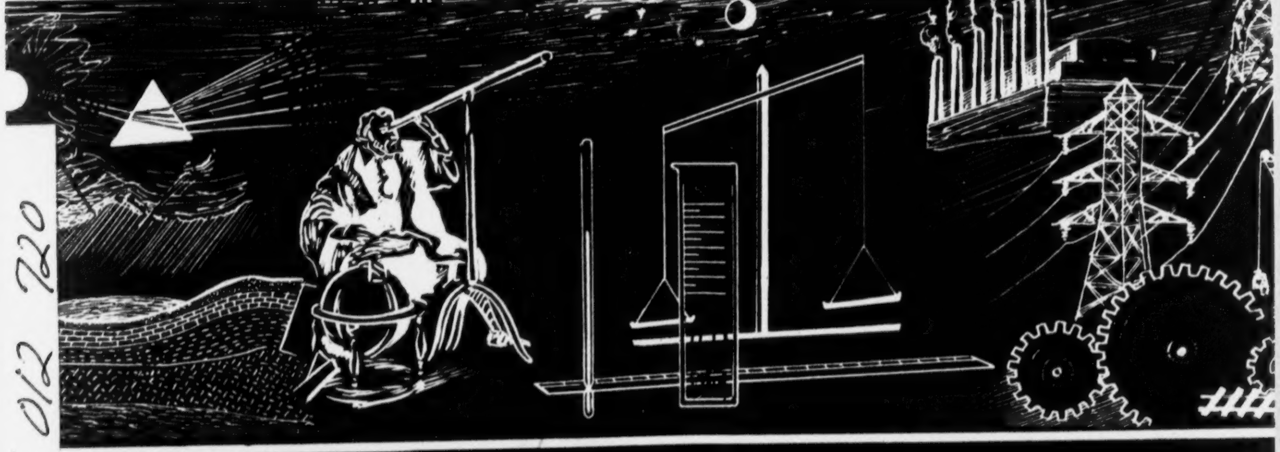
CURRICULUM GUIDE

PRIMARY

SCIENCE



SE 012 720

CURRICULUM GUIDE

PRIMARY SCIENCE

B. FOLLOWING ON

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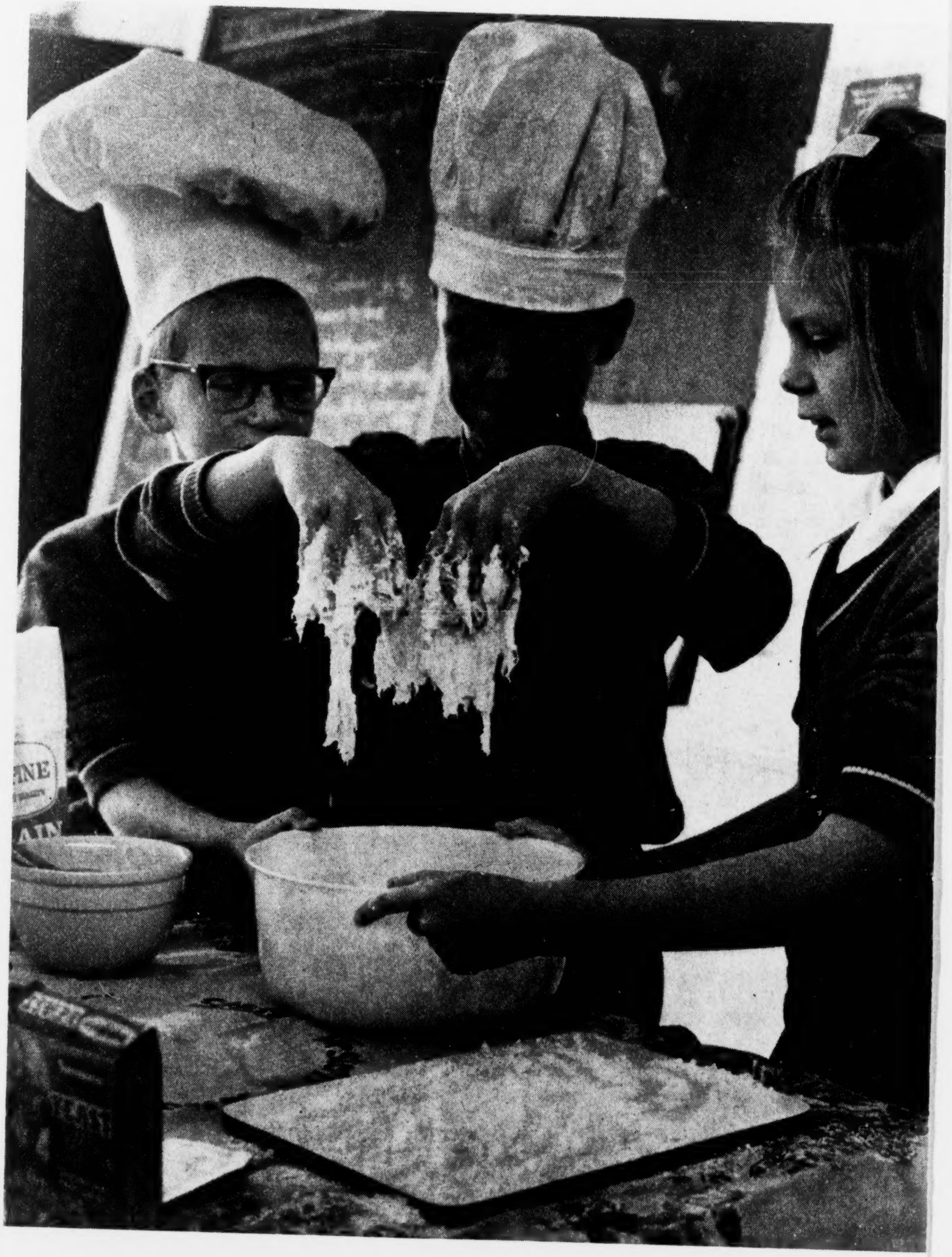

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NOTES ON USING THE CURRICULUM GUIDE

The Curriculum Guide contains many suggestions on methods of approach. It is suggested that the aims of the course are most likely to be achieved if children's interests are developed. A method that emphasizes instruction is not desirable. *The Curriculum Guide should be regarded simply as source material showing how ideas might be followed up. The units in the Guide should under no circumstances be regarded as outlines for class lessons.* Nor should the units be regarded as a complete description of possible activities. If work in science arises out of children's interests, and if the children are encouraged to develop their own lines of inquiry, it is to be expected that unit barriers (and subject barriers) will be broken down. For example, an investigation arising out of an interest in magnets might widen into what may appear to be, at first glance, a quite unrelated topic. Work with magnets might lead to an interest in electricity, which in turn might lead to investigations into heating and cooling, then into the making of coal-gas, a study of air, and, perhaps, might finish with a study of the breathing of animals. In this way work in the three main sections of the course—matter, energy, and life—can often arise naturally from one starting-point.

Such a flexible approach to the teaching of science is most desirable, particularly when it follows the natural interests of the children. For the aims of the course, refer to the *Course of Study for Primary Schools, Science*. The Course of Study also includes introductory remarks to the sections on matter, energy, and life.

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HOW TO BEGIN

AN INTRODUCTION TO THE CURRICULUM GUIDE

Refer to the primary science Curriculum Guide A—
Beginning Science.

DEVELOPING ABILITIES

Attitudes, factual knowledge, and skills—all are important in science. To consider each in isolation is dangerous if it detracts from the essential unity they should show. However, in this guide it has been necessary for some separation to occur. In this section skills are treated in some detail, but an attempt has also been made to show the relationship that exists between skills, factual knowledge, and attitudes. In all cases reference should be made to the appropriate units of work and the opportunities they provide for developing skills in a proper setting.

Certain skills have been mentioned in *Beginning Science*, which should be referred to for some understanding of the role of skills at the infant department level. In brief, however, skill development is regarded at the infant level as being a very informal process involving the following :

sensory discrimination,
observation,
grouping,
planning activities and carrying them out,
measurement,
organizing information (this includes presentation in the form of graphs), and
language work.

In the middle school an informal method of treatment should be continued, although the skills themselves are to some extent slightly more complex and differentiated, in accord with the growing maturity of the children. At this level the following skills are important :

observing,
categorizing,
measuring,
organizing,
inferring,
testing ideas, and
language.

It is worth noting that, in practice, a complete separation is impossible. Nevertheless, to clarify the meaning and the function of these processes, they are considered separately here.

OBSERVATION

What young children see is often determined largely by their emotional disposition at the time, their previous experience, and their physical positions as observers. Children tend to see what they want to see rather than what is really there. This can be verified if two coins, one light and one heavy, are dropped simultaneously from the same height. Unless they have had some prior experience, many eight-year-olds will say that the heavier coin falls more rapidly than the lighter coin, in spite of the visual evidence that they fall at the same rate.

Another feature of children's observations is that children give generalized impressions rather than those requiring careful scrutiny and accurate recording, for example :

> " The guinea-pig was very big."
>
> " A yabbie has bigger claws than a crab."
>
> (Early Grade III)

Where children write in this way, they should be encouraged to extend the range of their observations and at the same time make them more precise, perhaps using measurement, although this is not always necessary, for example :

> " A blue-tongued lizard is a peculiar reptile. He has a vivid blue tongue and does not bite. He makes himself inconspicuous by flattening himself. When he is scared he opens his mouth and his vivid blue tongue flicks at you. His eyes haven't got a lid. When we poked a stick at the reptile's eyes he turned them into his head. Only the white part was there. His ears are just a hole in the head and he does not hear very well. His head is like a spear head and when the weather is hot his blood is hot and when the weather is cold his blood gets cold. And he is a good meal for the aborigines."
>
> (Grade IV)

Sometimes a detail may capture attention and distract children from the study of more significant features. To overcome such tendencies it is often advisable to give some specific instructions to help children in their observations, but this does not mean that the teacher should tell all. This destroys any chance of the child's developing the skill to observe. Also, care must be taken not to impede the free flow of the child's own thinking. In practice, instructions should be confined to remarks such as :

> " Don't forget that there are magnifying glasses, rulers, and kitchen scales available for use, if you think they are necessary."
>
> " As you study the grasshoppers and the crickets, and compare them, note down in what ways they seem to differ and also the ways in which they seem similar."

It should be remembered that observations are made for a purpose and, therefore, generally arise in answer to a real problem. But too close attention to the problem may result in a neglect of other observations which may lead to the formulation of new problems.

Opportunity for developing skills in this area are legion, but the suggestions that follow may be useful.

Animals. Children observe carefully and write a description. On occasions it may be useful if other children attempt to name the animal after reading the description.

Behaviour Studies. Children note in detail the behaviour of an ant in an ant farm, a gold-fish in a tank, a snail, a worm, a white mouse feeding, or other suitable subjects, during a suitable period of time (3 to 5 minutes).

Movement Studies. During a similar short time period children note, in detail, the manner in which an animal moves. Interest may be heightened if comparisons of similarities and differences are made by a group studying worms, snails, millipedes, harlequin bugs, or other available creatures chosen for study either because they throw some common light on the problem of movement, or because of the contrasts that exist (as in the case of a worm and a millipede).

Seed Studies. Observations of seeds need not be limited to a study of external features, and to comparisons between seeds made on this basis. Older children should be encouraged to study the differences between the seed as it appears in a ripe bean or pea and its appearance in a seed packet. They may care to investigate the consequences of soaking dry seeds in liquids or of heating them before planting. Interesting comparisons might be made of peas and wattle seeds. Individual or class interest books on " What I found out about seeds ", which of course involve much more than observation, can be a focal point for the work and provide a link with English studies.

Other Plant and Fruit Studies. It is easier for young children to detect differences than similarities, and a good deal of observational work will therefore be directed along lines which will permit these differences to be noted. The following materials may be useful :

leaves of eucalypts, elms, beeches, liquidamber ;

pumpkin, mesembryanthemum (pig-face) ;

gum nuts ;

fruits in general—oranges and lemons; nectarines, peaches, and plums (particularly useful because the similarities and the differences intrigue young children) ;

cabbages and lettuces ;

nuts in the shell ;

legumes such as the sweet pea, the vegetable pea, and the bean.

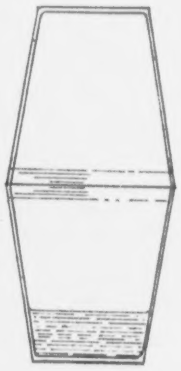
Soil Studies (involving comparisons between clays, sands, and loams that children can gather). Samples may have to be stirred into jars of water for observation. Magnifying glasses would be useful aids.

Studies of Effervescing Powders (including fruit and health salts, Dexsal, and bicarbonate of soda). Gases given off could be tested with a lighted match. Liquids other than water, such as vinegar and lemon juice, may be added to the powders. Some of this work would be an extension of infant school activities.

Observations and comparisons of heated sugar crystals, salt, copper sulphate, alum, Epsom salts, naphthalene, and iodine crystals.

Observations of the following :

(*a*) A quantity of water is placed in a glass and an inverted glass is attached by sticky tape, as shown in the diagram. The two glasses are then placed in a warm spot (a sunny window-ledge). Children should observe carefully what happens, and their report could become the basis of class discussion and further activity.



(*b*) Place ice-cubes in a tin and observe what happens to the dry outside surface of the tin.

(*c*) Observation of the behaviour of evaporating solutions —water and salt ; water and ink powder ; water and powder colour ; flavoured ice-blocks. These could be left in a sunny position, perhaps protected by net from flies.

The examples given above should be sufficient. In fact, every experience in science provides an opportunity for developing abilities in observation. The important point to remember is that it is not always enough to provide the opportunities. Wherever possible, systematic careful work, using the appropriate senses and aids, is essential to science work at any level, and development in observation can be and should be noted by the teacher from the oral descriptions children give as well as from their thoughtfully developed written work.

CATEGORIZATION

A mass of careful, detailed observations by themselves lead nowhere. It may be noted that some primary school children do not seem ready to go further. Even in the upper school there are children who seem content to give an account of what happens, or what is seen, without attempting to make or find any links between events or among the objects they study.

Yet the process of forming categories is essential if the child is to arrive at any ordered view of the environment, and at the same time develop concepts that enable higher levels of thinking to take place. Without the ability to classify and think in classes, the whole cognitive process seems impossible.

In *Beginning Science*, classification is encouraged, but the categories developed are those chosen by the children themselves, who should be able to justify their categories. Ability to classify develops with age, but it is very much an individual matter. Possibly the best procedure is to provide the experiences and encourage children to make the best possible use of these, bearing in mind the wide range of abilities that are present.

Infant department children tend to group on the basis of sensory evidence. They sort according to colour, taste, smell, and so on—that is, by concrete appearance. In the upper school it is more likely that children will begin to appreciate and make more abstract classifications, recognizing, for example, that certain animals such as whales and monkeys are members of a class despite the many observable differences. In the middle school it is likely that the tendencies mentioned above may both be present with, perhaps, another. As the children become more aware of the nature of the external world, features of human or animal activity and of use may loom larger, and one would expect these to appear in their systems of grouping. For example, children may be interested in distinguishing between plants useful to man and weeds, or between useful insects or birds and pests ; they may wish to classify ways of heating and cooling materials, or of insulating them ; and they may also group liquids according to use (for example, drinking, lubricating, flavouring, medicinal).

When studying seeds, children may care to classify those that produce oil (such as linseed and sunflower seeds and various nuts) and those seeds that are more suited to the production of flour. A classification of this type should be based on practical investigation, using seeds that are available from pet shops and from grocers.

Once again it must be emphasized that these activities should not be isolated but should form part of broader investigations into areas of interest.

MEASURING AND ORGANIZING

The development of skills in measuring and organizing, plus a growing tendency to use the appropriate measuring materials, should be a natural outcome of increasing ability to use the senses in observational work. Measurements of length, weight, volume, and time in science studies provide many opportunities for work with applied number at all levels.

Measuring

The units and the instruments used for measuring should be those appropriate to the situation. A balance made from a balsa-wood rod, with a needle for a fulcrum and two paper cake containers hanging from each arm of the balance, may be useful (see suggestions for work on liquids in *Branching Out*). With this balance, pins or paper clips would be appropriate units of measurement.

On another occasion a pendulum may be an appropriate timing device, using the number of swings rather than seconds as a measure of time.

When measuring the perimeter of a leaf, a length of wool or string might be an appropriate aid, or if the surface areas of leaves are being compared, seeds or buttons placed on the leaves might be useful.

The particular unit or measuring aid should be decided largely by the children themselves, and the development of ingenuity and creativeness should be encouraged.

Evaluation of changing attitudes and abilities in this area is a year-long process, and achievements and readiness to work with numbers need to be compared from activity to activity, where appropriate.

Organizing Information

Closely associated with measurement is the development of the ability to organize the information obtained. This may simply mean an orderly presentation of data in a paragraph ; it may also mean the construction of graphs and tables. Some samples of children's work follow :

Grade IV

(*a*) My scores for normal rate of breathing—

	A minute	
1st try	2nd try	3rd try
9	8	8
	For 1 minute after exertion	
16	14	15

(*b*) This attempt at organization was less successful.

4A Breathing Rate	Normal Rate			After Exertion		
80+ breaths per minute	1	1	..	5	7	7
70–80 ,, ,, ,, ...	..	1	..	2	1	..
60–70 ,, ,, ,, ...	1	..	1	5	3	5
●						
●						
●						
10 ,, ,, ,, ...	2	1	4	..	1	1

[In the above example it is difficult to decide what the table is meant to show, and this could provide an opportunity for the teacher to encourage children to be more critical in their approach to the task.]

(*c*) Do we all have the same hearing ?

We don't all have the same hearing. We experimented and some people had less hearing than others. When they could not hear the watch any more they said "stop". Then we got the tape measure and measured between the watch and our ear.

J.W.	12¼ in.	D.F.	7½ in.
J.O'B.	15 in.	G.V.	18 in.
G.P.	13¼ in.	P.B.	18 in.
S.W.	9 in.	D.H.	16 in.

Grade VI

(*a*) Pulling a board on asphalt

NAME	STARTING PULL	CONTINUING PULL
Tom	60 lb.	45 lb.
Colin	55 lb.	40 lb.
Mark	60 lb.	45 lb.
Pauline	45 lb.	37 lb.
Board on rollers		
Tom	9 lb.	5 lb.
Colin	10 lb.	7 lb.
Mark	9 lb.	9 lb.
Pauline	9 lb.	5 lb.

(*b*) The following example shows how an opportunity for clearer presentation was wasted :

"Heather's bicycle, which is a 28½ in. and has pedal arms 6½ in. long, turned 2½ times with one turn of the pedal and when it was turned five times it travelled 90 feet."

"Paul's bicycle, which is a 20 in. and has pedal arms 4½ in. long, turned 1¾ times with one turn of the pedal and when it was turned five times it travelled 51 feet."

"Mark's bicycle, which is a 27 in. and has pedal arms 6½ in. long, turned 2 times in first gear, 2½ times in second gear, and 3½ times in third gear with one turn of the pedal. When it was turned five times it travelled 70 feet in first gear, 90 feet in second gear, and 125 feet in third gear."

(The computations were made by the child. Their absolute accuracy does not concern us here.)

Graphs

Much of this work lends itself to graphical presentation, but even more important than the graph itself is the interpretation of the data it contains. This interpretation may be obtained from paragraphs children write under a heading such as : "What I found out from my graph."

BEYOND THE OBSERVATIONS

The mere making of observations is in itself inadequate. Children should be able to go beyond their observations and offer simple explanations (hypotheses, inferences, informed guesses) to account for what they have observed. Since explanations of these kinds will usually be uncertain, children should be encouraged to accept them only tentatively, and to express them in a manner which implies some doubt, for example:

"Perhaps the plant died through lack of water."

"Probably the plant died through lack of water."

"I think the plant died through lack of water."

These forms of expression are preferable to a definite statement such as: "The plant died through lack of water."

Children often give explanations for happenings in everyday life without considering alternative explanations. On looking through his bedroom window early one morning a child observes that the outside of the glass is wet. Having made this observation, he infers that it has been raining. He draws upon past experience in making this inference.

Another child, whose father is in the habit of rising early each fine morning to water the garden, would probably offer a different explanation:

"Perhaps daddy is up and has watered the garden."

He might go further than this, however, and add:

"or perhaps it has been raining."

It is at this stage that he must make further observations to support one or other of his explanations—

"Dad's bed is empty."

"The road is dry."

"The sky is clear."

These three observations support his first explanation.

"Dad is still in bed."

"The road is wet."

"There are dark clouds in the sky."

These latter three observations support the second explanation.

The following report from a Grade IV rural school child emphasizes the need for a tentative approach in attempting to account for the events observed. It also illustrates the importance of seeking and carefully considering alternative hypotheses and explanations.

"Today we put some soda and some vinegar together in a bottle. When we did that we put a balloon on top and it blew up. There was gas inside. The gas is from the soda."

Here the child has observed the production of a gas and has attempted to explain where the gas came from. However, from the same observations, another child might have said, "Perhaps the gas came from the vinegar " or " I think the gas came from the vinegar and soda when they were mixed together."

It is desirable in cases like this that the child should be encouraged to suggest further experiments to discover which explanation is correct, or at least to recognize that there may be, as in this case, more than one possible answer.

Opportunity for the child to make explanations occurs in all units. After several units have been completed, the teacher has the opportunity to create situations which enable the children to use the techniques and the knowledge they have gained from working through the units.

Evaluation Activities

Any evaluation of the child's progress in this area should—

1. draw upon the child's knowledge and understanding of the units ;
2. require him to make careful observations ;
3. require him to draw simple inferences ;
4. require him to undertake further activities to confirm his explanations.

The child who is required to make a report on his activities also gains practice in communication.

The following activity permits evaluation of the child's attitudes or abilities in this field. Several containers are filled with objects or substances such as sugar and iron filings, baking soda and iron filings, a steel ball, a moth-ball, brown sand and brown sugar, an alloy toy car, an iron toy car, and a magnet, as well as various liquids, common powders, and so on. The children are asked to discover what is in each container. They should make as many observations as possible, followed by inferences, before opening the containers to look at the contents. For example, each container might be rattled, weighed, or placed near a magnet.

The containers are then opened and the children are able to name some of the contents, but in order to be certain they would need to make further tests—for example, in the case of the two toy cars, to decide whether they were alloy or steel. The steel car would be attracted by a magnet whereas most alloys are not attracted by a magnet. Magnets would also be needed to separate the contents of the first two containers. It would be necessary to look, touch, smell, add liquids, heat, and devise as many tests as possible in order to identify the various materials.

Finally, here is another method of evaluation. The questions that follow should be asked at the end of the project.

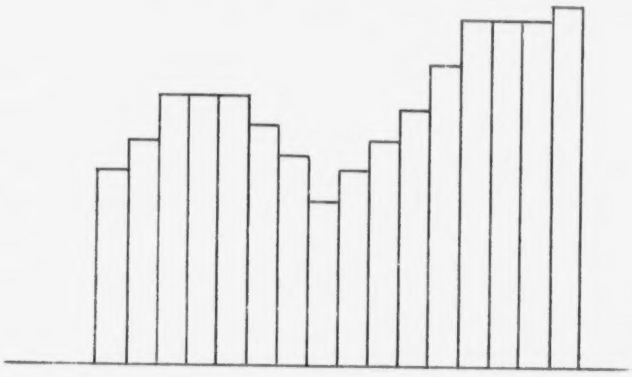
1. " Baby guinea-pigs are born fully covered with fur, and with their eyes open. Why do you think this is so ? "

   (Guinea-pigs are almost defenceless and they can only escape their enemies by running away. They survive because at birth they are at a relatively advanced stage of physical development and are able to take evasive action.)

2. " Some explorers found the body of a previously unknown creature in the jungles of South America. Its front teeth were like little chisels and were worn. Which of these foods do you think the creature ate : meat, ants, bark, grass, roots, nuts ? "

   (It is unlikely that it could eat meat or catch ants, but its teeth would have fitted it for handling the other foods if they were available. In the jungle there may have been little grass however, so we may presume that bark, roots, and nuts would have been suitable foods.)

3. " Here is the graph of the changes in an animal's weight :



   Can you tell anything about the animal from this ? Make up a story that would fit this picture."

   (Perhaps the animal was born, gained weight, and then became sick or was given insufficient food. Although it almost died, it gradually got better and developed steadily until it became an adult.)

4. " Suppose somebody gave you a strange animal and asked you to look after it, then left for England without telling you the proper food to give it. If no one could tell you, how would you find out ? "

   (Perhaps it would be possible to provide the animal with a variety of foods, and then watch to find its preferences. Alternatively, by looking carefully at its teeth and general structure, you might come to some conclusions about the suitable foods to provide.)

Whether or not the children give correct answers by adult standards is not really important. It is the way children set about answering such questions and discussing them that will tell if the scientific attitude is starting to develop.

TESTING IDEAS

Children's ability to test ideas develops gradually. In their early years at school, children are often uncritical, giving order to their experiences in a variety of ways, some of which are apparently irrational.

In one infant class a child observed that a plant on a shelf turned towards the window, and she explained this by saying that the plant wanted to see the other plants outside. Such primitive ideas need to be treated carefully, and with respect, so that the child's own ideas are not driven underground and hidden from view. However, in the same class there were children who thought along other lines and welcomed the opportunity to investigate. When working with plant growth they suggested and carried out some simple tests to determine the requirements for plant growth. Social interaction among the children usually ensures that this more advanced pattern of behaviour is assimilated by others.

Development is characterized by a growing readiness and ability to test, to see particular factors in a situation, and to apply controls. In the middle and the upper school a more critical attitude towards results becomes apparent, and with this there appears a tendency to regard results as provisional, although the extent of this varies from child to child.

Teaching Procedures

When a problem arises the children should be asked to offer explanations that will provide an adequate solution. Subsequently they should be asked how these explanations might be tested. Children who make suggestions may become leaders of groups which carry out tests and report back. There may be certain deficiencies in the methods proposed, but within limits it is better to let the children discover these for themselves. Finally, much of the incentive for subsequent activities can come from the work of the groups.

The case history that follows gives some indication of possible procedures, although they are by no means the only ones.

Problem : Does water make things go rotten ?

School : Small country rural school.

Grade level : III-V.

Period : Three weeks of observation and experiment.

This work followed on from growth experiments using wheat. One sample had been placed in a tin and left unwatered, whereas the second sample had been watered regularly. (The object of the initial experiment had been to investigate the necessity of water for germination. Near the completion of the observational work on germination it was noticed that mould was appearing on the second sample. When asked to comment, the children were adamant that the sample was going mouldy because it had water on it. Why water should make it go mouldy they could not explain.)

Using cake, banana skin, bread, baked bean, cheese, icing, apple, and wheat (children's lunches were the main sources of materials), the following experimental conditions were set up :

Dry specimens.
Specimens plus water in open containers.
Specimens completely covered with water in sealed containers.
Specimens completely covered with water plus Dettol in sealed containers.

The last two groups evolved from suggestions made by the teacher, who pointed out that both had air as well as water. At this stage no reason was given for adding Dettol.

(**Note.**—No hard and fast rule can be laid down about a teacher's suggestions. The extent to which suggestions should be used is dependent on many factors. It can only be hoped that experience will provide a sense of what is fitting.)

After a period of three weeks, the specimens in the open containers to which water had been added were quite mouldy. The dry specimens showed slight mould growth. Specimens in the last two groups showed no mouldiness at all. The children also noted that under these two sets of conditions no germination of wheat had occurred. This indicated to the children that water was not the sole factor influencing germination.

The children now agreed that something other than water caused things to rot. " Germs " were suggested and " bacteria " offered as an extension. A whole new field for activity had opened up.

LANGUAGE ABILITIES

In all school activities we should be concerned with *what* children think and also the *manner* in which they think about the intellectual experiences that the school environment provides. It is through their use of language that we can obtain some insight into children's thinking. The relationship between thought and language is complex and not fully understood, but there can be no doubting the closeness and the tremendous importance of the bonds existing between the two.

Among other things, language is a social tool with a double use, making possible communication from the teacher to the child and from the child to the teacher. The efficiency of this tool is dependent on the extent to which the persons involved are both receptive and articulate. Receptiveness on the part of the child is not simply a matter of his willingness to listen or of the teacher's ability to " place " his remarks at a suitable level, that is, at what is supposedly a " middle school " or an " upper school " level. The total social environment of the child and the meanings he applies to words are both important, and need to be understood and appreciated fully by the teacher. In the last analysis it is this social environment that often determines the values and the meanings words have, and indeed it can even limit the absolute number of words used. And, ultimately, this must affect the ability of the child to articulate his thoughts clearly.

The teacher must therefore be concerned in any educational situation with providing a rich language environment to make up for any deficiencies in this area, and to provide the framework of words which will facilitate the development of thought. Of course something more is needed, particularly at the primary school level. Purely verbal formulations and operations can lead to a glib superficiality. Concrete experience is essential. Language can then act as the mediator between thought and experience in real situations.

By encouraging a free and copious flow of words, both oral and written, and by developing a sensitivity to the implications of a child's particular style and choice of words, the teacher can gain insights into the developing thought processes of the individual child. Education as opposed to mere instruction can then proceed, on an individual basis, at an individual speed. Science provides a shared, social experience ; what is learned is dependent on the stage the individual child has reached.

Thus, the development of language abilities involves far more than producing a piece of recorded work—evidence that a certain area of knowledge has been treated in some fashion. Its significance goes far beyond picking up some skills in communication. In adult life not all children will become journalists or work with communications media, nor will many of them be concerned with the writing of reports and scientific papers, but it is a matter of the greatest concern that what we may term " internal communications " do occur and that the individual's own thinking is facilitated. Words are by no means the only system of symbols—brush marks on canvas and musical and mathematical notations are others—but words and language generally make up man's most unique and precious gift.

In science we provide a framework of language and experience of a certain kind, and it is essential that children be encouraged to use this, and that we as teachers help to develop language ability and, ultimately, thought itself.

The samples of written work below have been included to give some indication of this process in action. *The work represents neither the best nor the worst. In no sense are these extracts median samples from a particular grade level.* The overwhelming impressions gained from a study of the work of many children are of a great diversity in style, in level of operation, and of the individuality of the children themselves.

Preparatory Grade (November)

This work was done as part of a " Read, write, and draw " exercise. Children selected and wrote one or more sentences which had been composed by them and written on the chalkboard by the teacher.

(*a*) " We tried to stand on our shadows."

(*b*) " A shadow goes away when the sun goes in."

(*c*) " Our shadow shines on the ground."

Note the only partially developed idea of " shine " in the last sentence.

The children also composed and wrote their own sentences :

" I planted silver beet, now it has leaves. The leaves are green. There are eleven little leaves."

Grade I

This work is presented as it was written :

" We have some liquids one of them smell like a injection. You arnte aloud to taste them Because some are poisonus. Some smell like coffee, tea, vinegar, thay are smooth, stickey, thin. We can mix and it tickles, the Brown ones smell horrible. Brown sticks on the jar it ran down too a fro [few] are not poisonus."

Grade II

Air and Candles

"When you light a candle well when you put a jar over it the flame will go out. A fire needs air. When you light a candle the fire burns the wax."

The Heart

"If you get a heart attack a piece of fat blocks up the blood pipes. Our heart is a pump. It pumps the blood around the body then it comes back to the heart again. If you run [then] you can feel the heart beat faster because it is pumping more blood in your body the blood pipes are veins and arteries."

It is interesting to note how, even at this level, personal observation gets mixed up with information absorbed from TV, parents, and others. This is particularly true of the second extract. There is an interesting contrast between the limited observation of the first extract with its simpler structure, and the more developed style of the second extract. The "if—[then]—because" sentence-structure is not only stylistically significant; it is also a sign of a more advanced level of mental operation.

Grade III

Red-bellied Black Snake

"The snake has got a tail six inches long. He has got a red tongue. He is three feet long. The snake is black on top and red underneath. He has got black stripes underneath. The snake has got a nose. He has got a bone along the back. He has got a pointy tail. The snake is smooth underneath. The snake has got scales on top. He has got two eyes."

Change of State

(*a*) "When different substances are heated, different things take place. Some things such as fat melt into a liquid, other things such as moth-balls change into a gas, and others such as silver foil remain solid. When we melted candle wax and crayon and let it cool again in a pill tube it became solid in a little while. This is how we made candles."

(*b*) "Chocolate burns and other things like candle. We melted some candle and crayon and made a different coloured candle. Craig brought a spirit burner and that is what we melted the things with."

The differences in mental operation illustrated by these three samples are so obvious as to make comment unnecessary.

Grade IV

The Weight of Burnt Paper

"We tried an experiment with scales. We were trying to find out if it would make any difference to a certain piece of paper if we burnt it. First we got it dead level by putting matches on either side. Then we lit one side and as it burned the needle showed it was getting lighter. Therefore I think that paper that has been burnt is lighter than paper that hasn't been burnt."

Red-bellied Black Snake

"Today Annette brought a red-bellied black snake to school.

His tail was black all over and about six inches long.

If you feel on his back you could feel the backbone.

You can see the snakes eyes. He has no eyelids.

Inside his mouth is red, it looks as though his tongue is red, there is blood in his mouth.

The snake is about three feet.

If you look quite close you can see his nostrils.

Underneath you can see his scales.

He has diamond shapes along the sides of him.

On his back he looks as though he has sequins.

His scales lift up and under them is white.

On each of his sides it is very soft.

His tail comes to a very small point.

Underneath he looks like shiny plastic, it is smooth. He has dried up skin on the underneath near his head.

When you pick him up he feels as though his insides are moving."

It is interesting to note the greater precision of this extract compared with the Grade III extract on the same snake.

Grade V

Electricity from a Generator

"Generate ! What does this mean ? Generate means make and with an electric generator we made (or generated) electricity. At school we have a small generator out of an old-time telephone and it consists of four magnets, a handle and two lengths of wire on the outside.

Inside there is a large amount of copper wire, yards and yards of it, probably wound for hours on end, by hand, long ago. This is a simple generator—all you have to do is turn the handle but down at Yallourn you'd need either Superman or great machines to turn the 'handle'.

However, they use the mighty power of steam from millions and millions of gallons of water to send electricity all over Victoria. As you turn the handle of the generator the wires inside it spin in an invisible force (or magnetic) field and create a small current.

Be careful never ever touch a faulty switch when your body is wet for water is a very good conductor of electricity.

Another warning, if you ever see a small child near a connection with any kitchen utensil, tool, or small piece of steel yank him away and warn him never to touch one again."

Grade VI

These final two samples of work were produced by one boy. The degree of improvement is probably more apparent than in most work, but the writing does show definite development, if not a typical degree of development, and this should be the concern of the teacher and of each individual child taught.

Sound

> " Our grade made a double bass and we put a tuning fork on to the string and it vibrated. When you made the elastic band short it would make a high sound and if you made it long it would make a low vibration. We also made a tin-can telephone. You have to pull the string tight."

Air

> " During this week we have been doing experiments on air.
>
> The first experiment was on a red balloon which we put over a Florence flask. We heated the Florence flask and the balloon expanded. We took it off a stand where it was getting heated and let the Florence flask cool and the air contracted back into the Florence flask. Then the balloon went back down to where it started from.
>
> The second experiment was on an old tin which we heated. Then we put some cold water on it and the air pressed on it and when the air pressed on it, then the tin crushed up. The heating of the tin expanded the air out of the tin. When it cooled the air pressed on it and crushed the tin.
>
> The third experiment was on two plungers which we wet then stuck them together and tried to pull them apart, but we couldn't. At playtime we had about fifteen boys on each end and we couldn't pull them apart. This proves the air on the outside was pressing on the two plungers and there was no air pressing out in the inside. The air on the outside was pressing as you pulled and this makes it hard . . . "
>
> (The account goes on to describe other work.)

Some Teaching Points

Formal setting out—the use of headings such as " Apparatus ", " Method ", and " Conclusions "—tend to dry up the flow of thought from the child, producing instead what the child thinks the teacher wants rather than a genuine expression of individual thought and feeling.

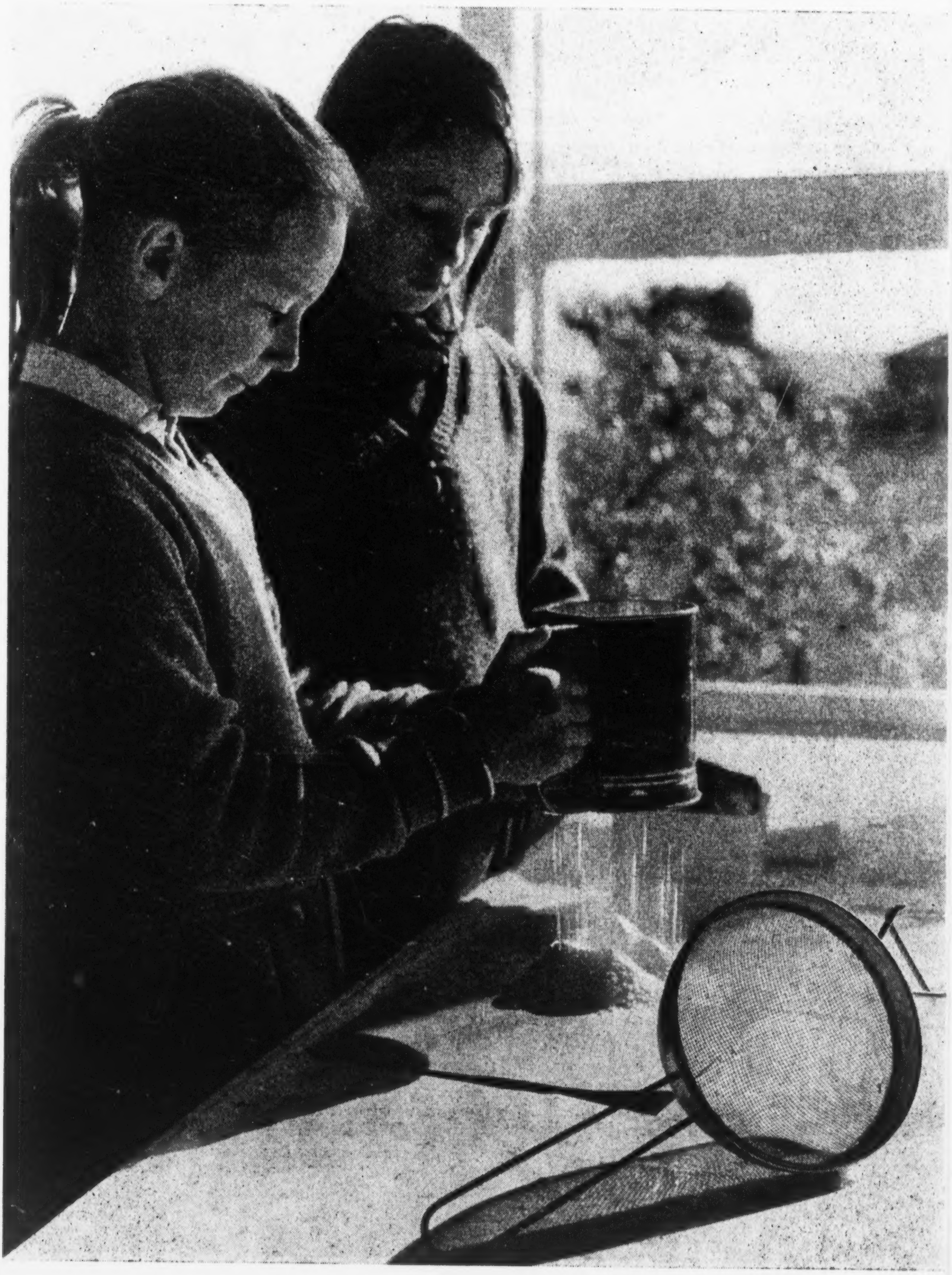
Corrections and suggestions for improving children's work need to be sensitive to individual needs and levels of achievement.

It has been noted that too abrupt a change from the methods and the materials of the infant room can be damaging at the Grade III level. Procedures in Grade III that will make entry into the middle school as smooth and gradual as possible should receive careful consideration.

2

PART I

MATTER



PART I : MATTER

For a full understanding of the material that follows it is essential to refer to the introductory remarks on matter in the *Course of Study for Primary Schools, Science.*

A. NATURE OF MATERIALS

COLLECTIONS

Refer to the *Course of Study for Primary Schools, Science,* Following On, Part I, Matter (page 6).

B. PROPERTIES AND CHANGE

SEPARATING MATERIALS

As in other units in this section, the general aim is to develop an awareness of qualities and properties of materials and of the relationships existing between them. At the conclusion of their activities, children should be able to use a knowledge of specific properties—magnetic attraction, solubility in water, solubility in methylated spirits, particle size, volatility—to enable them to separate materials they are investigating.

It is neither necessary nor desirable to group children's activities under such headings. It is preferable that children should experiment with a wide variety of materials, perhaps on the lines suggested in this unit, but it is their task to bring some order into the results and to organize the data obtained under suitable headings of their own choosing.

Introducing the Topic

The problems of sorting and separating a mixed collection of materials are both ancient and enduring. We sort the sheep from the goats and the wheat from the chaff, and we carry out this process with a multitude of other things in science, industry, and daily life. It may happen that an interest in processes of separation will arise in social studies. How do peasant communities throughout the world separate the grain from the husk? On the other hand, work with magnets, making solutions, evaporation, or soils provides opportunities for introducing these activities in a purely scientific setting.

For our present purpose let us assume that social studies has provided the starting-point. Wheat grains still attached to the husk may not be available. In some localities it may be possible to obtain some chaff, and this could be mixed with wheat. In other areas even this may be impossible, and the children should be encouraged to suggest materials that could be mixed with wheat, barley, or rice to simulate the materials peasants would have to separate. Here are some suggestions, but it is hoped that children will provide others :

wheat and cornflakes,
wheat and shredded paper,
wheat and confetti.

If either of the last two mixtures is used, keep the quantities small to minimize the problem of clearing up. Note in this, and in other situations, the range of suggestions that children offer. Their willingness to react with imagination tempered with realism when putting forward ideas gives some indication of whether scientific attitudes are developing.

If the wheat and the cornflakes are placed in a cloth or on a flat tray and tossed into the air on a windy day, or tossed up into the strong air current produced by an electric fan, the lighter flakes should be blown away and the grains will be left behind.

Separating Other Substances

Other substances could be collected and mixed. Here are some mixtures, but it is not suggested that all should be made :

sawdust and iron filings or pins
sugar and iron filings or pins

sugar and sand
salt and sand
salt or sugar and pepper or nutmeg

clay and sand, or other soil mixtures

salt or sugar and water

rice and talcum powder
baking soda and talcum powder

naphthalene or moth-balls and salt
iodine crystals and salt

wheat flakes and sand.

Separation of these pairs depends on lightness, solubility in water or methylated spirits, size of particles, and similar factors.

When salt and sand are mixed, the salt may be removed by dissolving it in water, which can then be poured off and evaporated.

Iodine dissolves in methylated spirits but salt does not ; salt dissolves in water but iodine does not or, at least, only to a slight extent. This suggests two methods of separating the substances.

Naphthalene or moth-balls float on water, while salt mixed with the naphthalene will dissolve in water.

Pepper and nutmeg do not dissolve.

Talcum powder is lighter than rice or baking soda, and sieving or winnowing may facilitate separation.

Iodine and naphthalene vaporize when heated.

Recording Results

The children should be encouraged to record their findings in some organized way suited to their level of development. Do not suggest a method of organizing data. Allow the children to build up their own schemes, which may be compared in subsequent class discussions.

Note.—It must be emphasized that the mixtures given here are *suggestions* only. The mixtures children use may be entirely different.

Separation encourages a deeper investigation of the properties of materials and permits the widening of ideas on classification and relationships outlined in the infant school guide. Therefore, these activities have a very serious intent.

SOAPS, FATS, AND OILS

It is expected that this unit will provide children with opportunities to gain a wider experience of certain materials. They will observe changes, both physical and chemical, although these changes will not be differentiated at this level. They will be able to note the effect of mixing oils with other substances including detergents, soaps, and weak alkalis to emulsify oils and fats and produce materials with properties different from those possessed by the originals.

It is also expected that opportunities will arise to develop children's abilities—

- to handle situations in which a number of variables are involved ;
- to extract conclusions consistent with the data obtained from a number of investigations ;
- to write clear accounts of their activities, stating conclusions in a manner consistent with the level of ability at which the children are operating ;
- to develop interest in further investigations which would be closely linked with work in social studies.

Interest may arise out of work in social studies, say from an examination of peanuts, coconuts, or soap. At some stage, if a desire to collect and compare different fats and oils manifests itself, the following suggestions may prove useful.

First, it is useful to have some means of testing whether or not a substance is an oil. Most children are aware that the butter in their sandwiches or the fat in their lunch-time meat pie will cause paper to become semi-transparent. After comparing this effect with the effect of putting water or lemonade on paper, they may justifiably decide that the " paper test " provides a rough but usable guide.

The collection of various fats and oils should be undertaken, and children can make groupings of these, deciding categories for themselves—for example, colourless, coloured ; thin, thick ; made from plants ; produced by fish, sheep, cattle, and so on. This may lead children to attempt the extraction of oil from various materials. Although the amounts obtained may be small, they may be detected by applying the paper test. Activities undertaken might involve the pounding of peanuts and other available nuts ; crushing sunflower seeds or linseed ; drying the white " meat " of a coconut, then crushing it ; collecting the wax comb made by bees. If children wipe paper over their noses or hair they may observe that the human body also produces oil.

Emulsifying Fats and Oils

Another collection, this time of detergents (including soaps), should also be made. Grouping will no doubt occur—liquid and powder detergents ; powder, bar, and flake soap—and some children may wish to compare the efficiency of the various products collected. Before doing so, close examination should be made of the changes that occur when soap and oil are mixed in water. This stage offers valuable opportunities for developing skills in handling a number of separate activities and drawing conclusions from the observed results. The children will have on hand a number of fats and oils and a number of detergents, including soap. They could try different combinations of these and note the results. They may wish to discover which combination of detergent with fat breaks up the fat most easily when shaken. The sizes of the pieces of fat would need to be considered. For example, it would be unscientific to compare a large piece of mutton fat and a small piece of bacon fat. It would be necessary to time the shaking and measure the quantities of detergent and water used. A large amount of data can be collected from a small number of samples treated in this way. Encourage children to organize the data themselves. Some of them may do it in the following way :

Fat/Oil	Detergent	Time of shaking	Hot or cold water	Result
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—

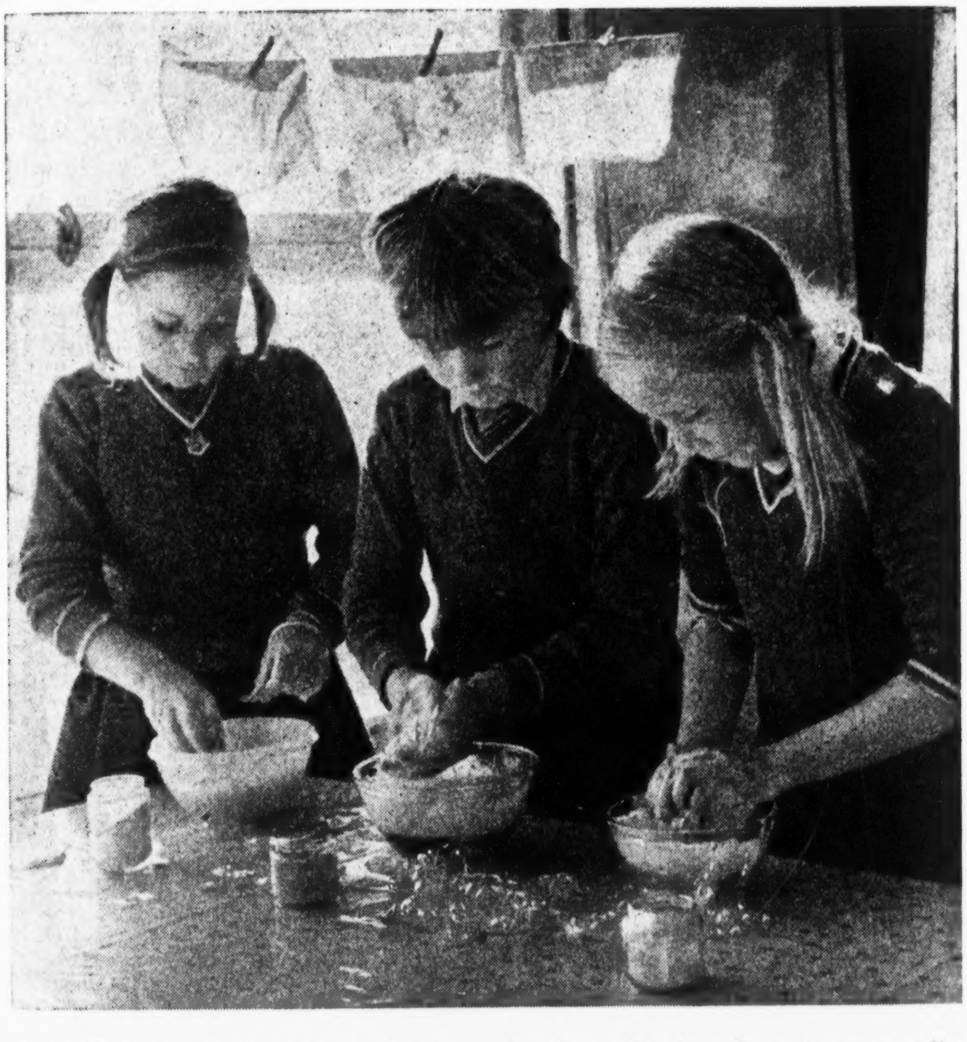
Note.—Small quantities are sufficient. Use a number of small shaking jars rather than a few large bottles. During their activities, it is expected that children will observe and comment on the fact that the fats and the oils tend to break up into small globules. This is due to the molecular attraction at the surface being weakened, but this need not concern children at this level.

Comparisons of Cleaning Efficiency

Children may decide to plan and carry out their own experiments to determine the efficiency of various products as cleaning agents. This may involve placing small measured quantities of mud, shoe polish, or grease on cloths and then agitating these on sticks in warm water for a given time. This is just one suggestion ; rather than follow this rigidly, it is better that children's initiative should be encouraged.

Making Soap

The lathering qualities of various detergents and soaps will no doubt have been investigated by the children. They may have compared lathering by shaking up measured quantities of soap and water in tall soft-drink bottles. If this is done, it might be advisable to warn them



that efficiency as cleaners and the production of lather do not necessarily go together.

Some children may point out that certain plants also are "soapy" (that is, they will lather). Two examples are the flower spikes of *Ceanothus*, frequently found in home gardens and known as "Blue Bush", and the leaves and twigs of a tree, *Quillaja*. The roots of *Gypsophila* are also capable of producing a lather. Among primitive people lather-producing plants are widely used as a substitute for soap.

The early pioneers also faced the problem of making their own soap, and it may be possible for children to attempt this task for themselves. Basically, the process consists of combining an alkali with a fat. Alkalis such as caustic soda are dangerous, but a mild alkali can be made in pioneer style by washing potassium carbonate out of wood ash with water. The ash could be placed in a tin in the bottom of which nail holes have been pierced. Place a layer of cotton-wool in the tin to filter the water. Pass the water through the ash a number of times to strengthen the solution which is called "lye". Alternatively, the lye can be made by soaking ash in a tin of water for several days. Experiment will show which method is more successful.

The lye should now be added to the fat. Clean, unsalted dripping is needed, and the mother of a class member may obtain this. Beef or mutton fat is boiled gently in water for about ten minutes. When it cools, a solid cake of usable fat can be lifted out. The soap is made by adding about two ounces of this fat to half a pint of lye solution and simmering for half an hour or longer if necessary. If the lye is strong, all the fat will be absorbed and a little more can be added.

When the mixture cools, an almost clear jelly should form. This is soft soap. It may be put into water for washing purposes or spread on soiled materials which can then be washed or scrubbed. Some classes may care to discover whether a small quantity of olive oil could be used as a substitute for fat in making soft soap.

In earlier times, ashes were boiled with the fat to make an abrasive soap. This suggests another method of soap-making that could be tried.

The valuable links with social studies that this activity could provide need no further emphasis.

Note.—Children should realize that their first attempts to make soft soap may fail. They should be prepared to examine their methods and attempt to find the cause of their failure. *Finding and correcting mistakes is a valuable part of any work in science.*

WATER IN FOOD

This unit should provide children with opportunities to observe the mainly physical changes that take place when water is removed from or added to foodstuffs. At the conclusion of their activities children should be aware that many foodstuffs contain water ; that foodstuffs may be preserved by removing water ; and that it is possible to measure the amount of water present in many of the foods we eat.

The activities themselves provide a number of opportunities for children to improve their ability to make suitable weighing devices to determine whether changes have occurred ; to measure, organize, and record data ; and to make simple tables, charts, and graphs.

In a limited way the activities described here can provide an introduction to the idea of reversibility of change, and to analysis, as well as extending children's ideas on the complexity of substances ; in this case, that water may be present even when it cannot be seen in its normal form.

Introducing the Topic

The topic of water in food may develop from work in social studies, from preparation for a food stall run by the mothers' club or the social service league, or from science units on heat, liquids, or matter. Work in this unit may be regarded as part of the social studies course. However, if this is done, *the aims of the science unit must not be forgotten.* The development of abilities in measuring (weighing) and recording of results in table or graph form may well form part of mathematics periods.

Water in Our Food

By examining a variety of foods, children will discover that most of our foods contain water. However, some foods will appear to be quite dry. In most cases this will be because the food is " stale " or has been processed by man. Children should be able to suggest what has happened to the water, particularly if the unit on evaporation has been completed. This should lead to investigation of the effects of heat on food.

The Effects of Heat on Food

The source of heat may be the sun, a stove, or a lamp. Activities may include weighing the material before, during, and after heating, and tabulating the results daily. A suitable balance can be made from a one-foot piece of lath. Make a hole at the mid-point of the lath and place a nail to fit loosely through this. Children will need to make a simple framework to support the balance. A paper cake cup hung at each end of the lath would serve to hold the drying food and the weights, which might be pins or paper clips. Children can then express the weights of the foods as being equal to " so many pins ". Observing the changes that take place and using the senses of sight, smell, touch, and taste should interest most of the children.

Steam may be seen rising from the food when it is being heated. If food such as lettuce, celery, cabbage, and so on is heated in a closed container (a test-tube or a can with press-on lid), moisture may be observed on the inside of the container when it has cooled. (Refer to the unit on evaporation in Heating and Cooling.)

Children may be expected to comment on the changes they observe. Any inferences children make should be based on their own observations. They should be aware of the desirability of testing their inferences.

Why Does Man Dry Food ?

The children will probably want to know why man dries food. It is neither necessary nor desirable for the teacher to give a direct answer to this, since the children may well supply the answer from their experiences in this unit.

If a number of foodstuffs, including some dried foods, are kept for some time, the children will observe less change (decay) in the dried foods than in the others. (Refer to the unit on decay and preservation in Life Stories.) Through discussion, the children should come to realize that foods may be preserved by drying.

Dried Foods in the Home

Ask the children to bring samples of dried foods from home. (The term " dried " is preferred to " dry " as some " dried " foods retain an observable amount of water, for example, dried fruits such as raisins and prunes.)

Allow the children to add water to the dried foods and to record the results—changes in appearance, weight, taste, smell, size, etc. For example, if dried dog food is placed in a bowl and water is added, the water is soon absorbed by the dog food. The changes that take place are obvious. The weight and the volume of water absorbed by a set amount of the dog food may be measured and compared with other dried foods treated in this way, and the data thus obtained organized and recorded. Recording may take the form of written descriptions, graphs, or tables of results. The children should be free to suggest and carry out similar experiments and to organize the data in their own way.

Children may now wish to carry out the reverse procedure, that is, to return the moistened food to a dried state. Once again careful observation and measurement are desirable. More advanced children may even find their own method of condensing the water vapour given off in the drying process and collecting and measuring the water, although the results of this would probably be rather inaccurate.

Children will come to realize that the stated weight of a container of processed food may depend to a large extent on the water content of the food. A comparison of dried dog food and canned dog food should prove interesting.

Fruit-drying for Home Use

Suitable Fruits : Apricots, apples, pears, peaches, plums (prunes), grapes (sultanas, currants, raisins), cherries, figs.

Equipment : The only pieces of equipment needed are wooden trays, on which the fruit is placed while drying, and some netting to protect the drying fruit.

General Procedure : The fruit, either whole or sliced, is spread on the wooden trays and placed in the sun to dry. The length of time required for drying varies according to the type of fruit, the size of pieces, the weather, and so on, and is a suitable topic for investigation by the children.

Preferred Varieties—

Apples—white-fleshed, firm, Granny Smiths.

Pears—Williams' Bon Chretien.

Peaches—yellow, firm-fleshed, free-stone.

Grapes—ripe Gordo grapes for lexias or pudding raisins ;
sultanas ;
currants (leave on bunch) ;
muscatels (or dessert raisins—leave on bunch).

Children may observe and record the changes that take place and suggest reasons for any variation in results. Vegetables such as onions and carrots may also be dried.

Note.—If at some later date teachers are interested in a fuller description of the methods used to dry fruit, they should refer to the Department of Agriculture, Victoria : Bulletin No. 43, *Preserving Fruits and Vegetables.*

Further Investigations

Herbs and Grasses. Further experiences may include investigations into the drying of flowers, stems, and leaves of various plants, including herbs, for decoration or for use in cooking. Drying may be carried out in an airy room or in a cool oven.

The making of grass or oaten hay or the drying out of lawn clippings may also be investigated. Changes in weight could be determined, and it might also be possible to devise a situation in which the rotting of green grass, perhaps in a pile of moist lawn clippings, could be compared with the keeping qualities of dry clippings. This could provide a link with social studies and the farmer's work, and also an opportunity to introduce activities concerned with the problems of break-down and decay of living material.

PLASTER AND CEMENT

It is expected that these activities will provide opportunities for children to learn more about the nature of certain materials, and at the same time to design tests for strength, to practise the timing of events, and, in general, to work systematically.

How Work Might Begin

Many topics in this section on Matter are likely to arise naturally from work in social studies, and this topic is no exception. For example, an interest in plaster, cement, and similar materials may be developed out of work on homes, or perhaps as a result of a class visit to a nearby building site. Other starting-points might be a plaster cast around a child's broken arm or leg ; making casts of animal footprints, leaves, or children's hands ; or attempting to make simple plaster moulds. On the other hand the nature of the materials is intrinsically interesting to children, and no introduction may be necessary. Simply ask the children to bring the materials to school. Some possible activities are given below.

Making " Bricks "

If children bring materials such as clay, various earths, sand, lime (hydrated lime or Limil), builder's plaster (from a hardware store), plaster of Paris (from a chemist), cement jointing mastics, and putty and other wood fillers, they may care to make " bricks ". First they should compare the materials carefully, using any inspection tests that they can devise—they may feel the materials, examine them under a lens, perhaps even smell them.

Suitable moulds for the " bricks " would be matchboxes. Compare the suitability of the box and the cover as moulds. Children may wish to use other containers ; sometimes it may be advisable to coat the inner surface of the mould with vaseline so that the brick can be removed easily.

Some of the bricks could be used later for building walls to show the various ways in which brick walls are bonded together. Most encyclopedias contain some information on this subject, and observations could be made of the types of bonding used for building work in the vicinity.

Setting Times

Some children may wish to carry out tests to discover how long it takes various materials to set. Plaster of Paris sets very rapidly, faster than cement, which may take many hours. It would be necessary to decide on some way of determining whether the material had set. Children might suggest a " finger-nail " test or use a pencil to poke at the surface.

Encourage the children to devise a table or a graph that will enable them to record results and make comparisons.

Testing for Strength

Children may also wish to compare the strengths of the bricks, and here again their suggestions as to how this might be done should be tried. In one class children tried dropping a marble a number of times from a table-top on to a brick until it cracked. They then worked with different types of bricks and compared the number of times the marble needed to be dropped to break each type.

Another possible method would be to try dropping the brick from increasing heights until the brick broke. A third method would be to drop a quarter-pound or a half-pound weight from one inch, two inches, three inches, and so on above the brick, increasing the height until the brick broke. A ruler would be needed to measure heights.

Making and Testing Mixtures

Concrete is a mixture of sand, small stones (aggregate), and cement, and it is stronger than straight cement. Similarly, other mixtures may be stronger than a single substance—plaster and fibre such as plasterers use ; plaster and sand ; plaster of Paris and rag ; plaster and gravel ; cement and sand ; cement and gravel ; cement, sand, and aggregate in various proportions (building workers should be asked what proportions they use).

Other Activities

While the above activities are being undertaken, further lines of inquiry might open up, as suggested by questions such as the following :

> Will these substances set when mixed with liquids other than water ? (Say, vinegar, oil, methylated spirits, perhaps even honey.)
>
> What happens when you crush up the set brick and mix it with water again ? Will it set ?
>
> Will the brick set in the rain or under water ? (Concrete will set.)
>
> Where do plaster, cement, and other materials come from ?
>
> How are these materials made ?
>
> Could we make cement ?
>
> Could we make our own lime from shells ?

It is unlikely that children will succeed in making cement or lime, but trying to do so and searching for information might still be valuable.

Following these activities, a return visit to the building site, an examination of mortar adhering to old bricks, an examination of various materials around the school itself, and an investigation of building processes used in the past might be profitable and lead to further activities.

This topic could also lead to making Interest Books ; creating classroom displays of building material, which could be illustrated with diagrams or paintings showing uses; and developing applied number work.

SOLUTIONS, GROWING CRYSTALS, ROCK CANDY

Interest in this topic may develop in a number of ways, perhaps as a result of—

extending observations of powders and crystals, begun in the infant department ;
looking at collections of objects through magnifying glasses ;
working with rocks, quartz crystals, and other crystalline forms brought along by children whose parents are enthusiastic collectors of semi-precious stones ;
building on the latent interest in dissolving and mixing things.

During their activities children should be encouraged to discuss what they observe, to put forward ideas to explain what happens to the substances when placed in the liquids, and, in the case of substances which dissolve, to attempt to explain where the substances " go ".

The topic also provides opportunities for developing abilities—in particular, organizing data on the amounts used, times taken, and temperatures (at this level " hot ", " warm ", and " cold " would be satisfactory and the thermometer need only be a child's finger). Children should also be encouraged to draw conclusions consistent with the data as to the relative solubility of the substances tested and the effectiveness of the different liquids as solvents.

Materials

Small quantities of water, light oil, kerosene, methylated spirits, turpentine, and vinegar would be useful as solvents. Substances to dissolve in these liquids might include sugar, salt, powder colour, chalk, copper sulphate, photographer's " hypo ", alum, lawn " food ", ball-point pen fluid, green grass clippings, iodine crystals, boot polish, Bostik, and dripping. It is not necessary for all of these to be used.

Some of the activities children might undertake are as follows :

Dissolving Substances. Combinations of substances and liquids collected by children should be tried, and the findings organized by the children themselves. They may investigate the effect of raising and lowering the temperature, and discover the difference between substances which actually dissolve and those which only form suspensions in the liquids before finally settling at the bottom of the jars.

Evaporating Solutions and Suspensions. Small quantities of the solutions could be placed in shallow dishes and allowed to evaporate in the sun or over a heater. Magnifying glasses are useful for examining the residues. When a known quantity of salt or sugar has been dissolved in water, the children could evaporate the solution to determine whether there is an equal quantity of residue.

Growing Crystals. Crystals will form slowly as the solutions evaporate. The process can be speeded up somewhat. Use half a glass of very hot water. Stir in as much of the substance (sugar, salt, alum, or copper sulphate) as the water will hold. Suspend a cotton thread, weighted with a metal nut, in the solution and crystals will form on the thread. When the thread is removed from the liquid and placed on black paper the crystals can be observed under a microscope or a magnifying glass. Larger strings of crystals can be formed if the saturated solution is poured into a shallow dish and threads are laid across the surface.

Some children may care to grow crystals. Let them prepare a second solution into which the thread of crystals can be placed. Crystals of sugar produced in this way are sometimes known as " rock candy ", and their ultimate destination is obvious.

A Link with Health and Safety. If crystals of copper sulphate, alum, or " hypo " are made, warnings should be issued about tasting. These activities should provide a good opportunity to start safety discussions on the potential dangers of many household substances. This process of issuing warnings to the children should continue from year to year.

BREAD, TOFFEE, HONEYCOMB, GINGER BEER, AND CHEESE

One necessary ingredient for success in any program of work is variety. The unit suggested below represents an attempt to provide variety. It does not deal with physical forces or living things, but the attitudes involved are the same as in the other units. Children come face to face with problems. To solve them they must plan and carry out activities. Children should learn something of the causes and the characteristics of physical and chemical changes.

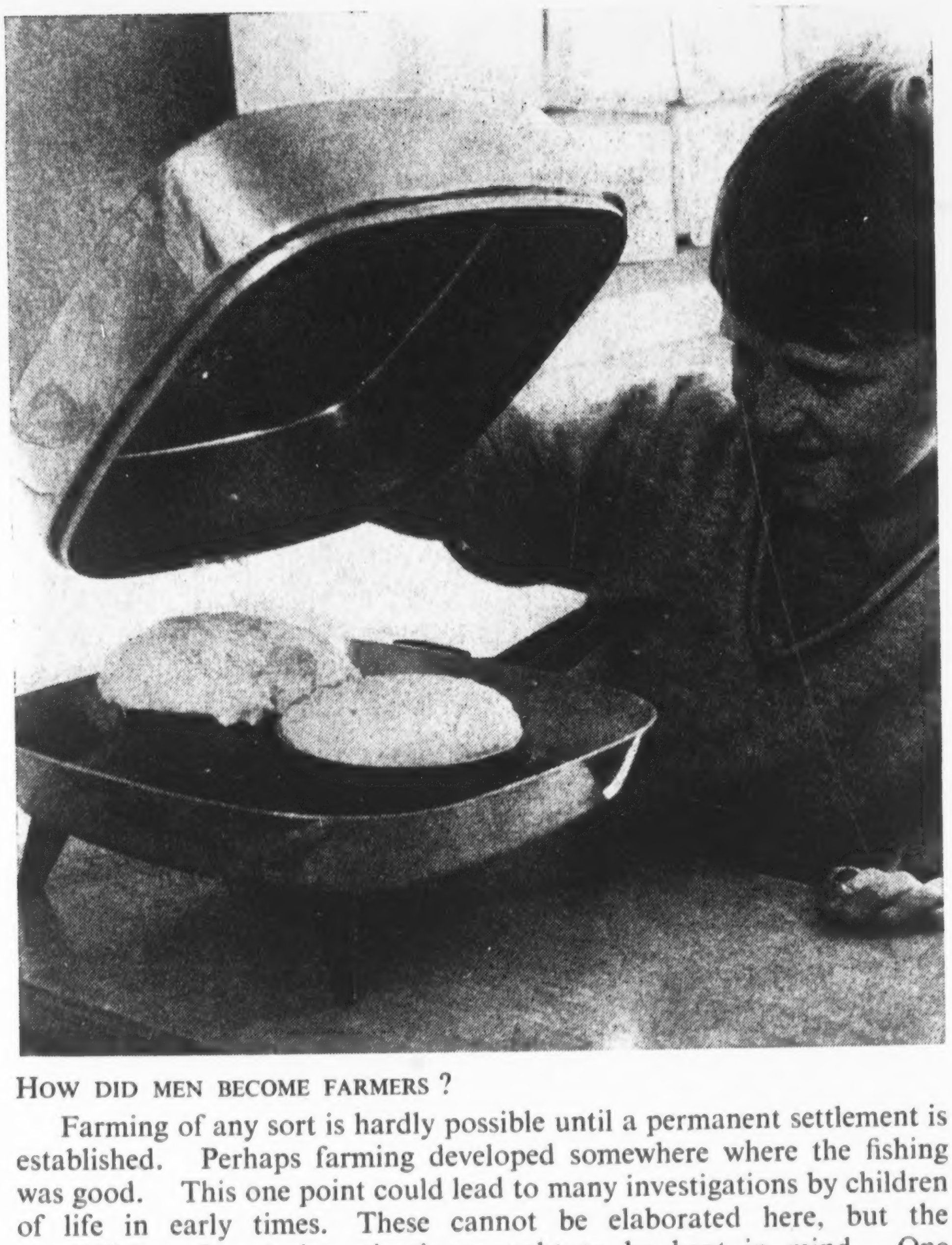
Note that the subject-matter of this unit is closely linked to work in social studies. In fact, some teachers may think of it as social studies rather than science, but it should be noted that certain scientific attitudes are being developed. The unit not only links social studies, some manipulative skills, and science, but also English, for the unit would not be complete without the children's own accounts of their adventures. If science does link with other subjects it helps " to eradicate the fatal disconnexion of subjects which kills the vitality of our modern curriculum." (A. N. Whitehead).

The unit is divided into five main sections headed Bread, Toffee, Honeycomb, Ginger Beer, and Cheese. In each section, children will find opportunity to observe reactions and changes, organize and record information, measure, and plan and carry out simple experiments.

Bread

Introducing the Topic

This section might start naturally in many ways—through talking about the life of early man or our foods, growing seeds, looking at seeding grasses, or through talking about and examining different types of bread.



HOW DID MEN BECOME FARMERS ?

Farming of any sort is hardly possible until a permanent settlement is established. Perhaps farming developed somewhere where the fishing was good. This one point could lead to many investigations by children of life in early times. These cannot be elaborated here, but the possibilities of such investigations ought to be kept in mind. One problem children might wish to tackle is : How did early man till the ground ? The children may like to try making a plough with a pointed stick and then using it to scratch the surface of the soil. Or they may discuss why the aborigines did not become farmers.

HOW COULD WE GROW A CROP IN THE WAY THAT EARLY MAN DID ?

It would make sense to ask this question when grasses are seeding on vacant allotments or in paddocks near the school. Children could try gathering grass and weed seeds and planting them in a suitable place.

WHAT DID MEN DO WITH THE SEED CROPS THEY HARVESTED ?

Children might make up various theories about this, but eventually they should mention that early man must have learnt to make bread.

COULD WE MAKE BREAD FROM WHEAT ?

HOW COULD WE MAKE FLOUR FROM WHEAT ?

Let children suggest and try methods for making it. In one school a group of children attempted to crush wheat, using two bricks. It was obvious to the teacher that this would be unsatisfactory. After working for some time it also became obvious to the children as brick particles became mixed with the " flour ". Eventually the children developed a superior technique and produced some passable flour, using a hammer and a slab of concrete to crush the wheat.

This example has been included to emphasize that it is important to let children experiment with their methods until they, not the teacher, develop one which is satisfactory.

HOW COULD WE MAKE THE DOUGH ?

The flour should then be mixed with water, the dough kneaded, and the loaf baked at a child's home or in the school oven or an electric fry-pan if available.

HOW COULD WE MAKE BREAD THAT WILL RISE ?

This may involve a trip to a local bakery and reference reading in the library. A study of yeast and its action would follow. Perhaps a group might try to make some bread with yeast and refined flour.

COULD WE MAKE DOUGH RISE WITHOUT BUYING YEAST ?

At this stage, the teacher will have to play a more active part in the work by supplying information and perhaps offering assistance. Even so, the children may not be successful in solving this problem. Perhaps this does not matter.

Early man made a very moist dough with crushed grain, and it was noted that if some of this dough was left in a warm, moist place, it would go sour and become crumbly and soft. The dough soured because yeast germs, which are present in the air, fell into it. When this soured dough was mixed with the fresh dough, the loaf rose. In some parts of the world, bread is still made in this way. It would be worth trying at school.

In this unit, the children should be presented with problems to solve and activities to try out as far as possible on their own or in groups. By so doing, they can practise methods that are at the heart of the scientific process.

Toffee

Note.—In both this section and the one that follows, the activities suggested ought not to be regarded as being suitable for the whole class to perform. Instead, a small group might undertake the work, using fruit tins as cooking pots and tablets of solid fuel as sources of heat. The work might not be carried out as part of a formal science period, but could be undertaken in the children's own time. Keep the science " period ", if there is such a time, for discussion of results and planning of subsequent activities.

Introducing the Topic

The teacher may seek the co-operation of parents or the mothers' club to make a supply of toffee for the children's inspection. Much of the work would probably be more successful if completed in one day and not announced beforehand. This should overcome the problem of children obtaining the information about ingredients and methods from home.

If children are allowed to examine plain home-made toffee, taste it, touch it, crush it, and so on (particularly if they have covered work in the units Solutions, Crystals, and Rock Candy, and Water in Food), they should be able to suggest what ingredients are used in making toffee.

Suggested Activities

The children now have the opportunity to test their ideas. It is expected that they will suggest making toffee from sugar and water. Allow the children to experiment and develop their own method of toffee-making. They should be interested in the changes that take place in the two basic ingredients as the experiment proceeds, and may find some connexion with the unit Water in Food.

Children may be expected to keep a careful record of the ingredients and the methods used. Measuring activities (weight, capacity, time) are involved and data may be organized into recipe-type descriptions, tables, or graphs.

Other questions investigated might include : " Do the results vary if we add more sugar or more water ? " " Does the amount of heat make any difference ? "

As a final activity, children could compare their methods with those suggested in cookery books. Recipes will be found under the headings Toffee, Barley Sugar, and Taffy, and while the many recipes will vary as to ingredients and methods, any which use sugar and water as the basic ingredients are suitable. Children will probably wish to pursue this topic further by making toffee at home, adding flavourings, colouring, and so on.

Honeycomb

Introducing the Topic

This topic may be introduced following the work in the section on Toffee, and much the same procedure adopted. Allow the children to examine some honeycomb. They should once again observe that it is sweet, suggesting the presence of sugar, and that some moisture (water) is present. They should also notice the many tiny bubbles in the honeycomb, and recognize this as something worth investigating.

HOW DID THE BUBBLES GET THERE?

The children should have had experience with liquids, powders, and gases in the infant school (refer to *Beginning Science*) and perhaps in the middle school during investigation into the properties of household substances. They will be familiar with fruit saline, sodium bicarbonate (bicarbonate of soda), and several medicinal powders which create bubbles when mixed with water.

The children might try many methods to make the bubbles, for example, blowing into the liquid through straws, shaking, agitating with an egg-beater. Allow the children to experiment, even if it is obvious to an adult that the methods they are using will fail.

If after some time the children have still not suggested using bicarbonate of soda or some similar powder, leave this topic for a while and introduce some experiences with powders and liquids. If the problem of making the bubbles in honeycomb is kept in mind, experiences with bicarbonate of soda may lead to its use in making honeycomb.

Honeycomb Recipe

This recipe need not be shown to the children until the final stage of the topic when they may wish to compare it with their own recipes.

Ingredients (the actual quantities used may be smaller, depending on the size of the containers children work with) :

2 tablespoons golden syrup
2 tablespoons sugar
1 teaspoon bicarbonate of soda

Directions : Boil the syrup and sugar gently for ten minutes.
Remove from heat.
Stir in soda.
While still bubbling, pour into a greased baking dish.

A syrup made from brown sugar and water heated together as for toffee-making can be substituted for the golden syrup. Children will be interested to compare the two types of honeycomb.

Disposing of any surplus honeycomb should present no problem.

Recipes for ginger beer and cheese have been included in this unit to provide a basis for further experiences similar to those in the first three sections.

During this work, teachers should keep in mind the objectives set out for this unit. Children should be encouraged to plan investigations based on their experiences in the previous sections. Small groups of children or individuals could carry out the activities, using smaller quantities of ingredients.

Ginger Beer

Children often make this at home by " feeding " a ginger-beer " plant ". Where this is not available, the following recipe may be useful and lead to speculation about the nature and the properties of yeast.

Ingredients : 1 or 2 lemons
1 lb. sugar
4 oz. root ginger
1 oz. cream of tartar
10 pints boiling water
1 tablespoon yeast

Directions : Pare the rind from the lemons thinly ; extract and reserve the juice.
Bruise the ginger.
Put all the ingredients except the yeast and the lemon juice into a container (basin, bucket, crock) and allow to cool till blood warm.
Cream the yeast by mixing with a little sugar.
Add the creamed yeast.
Allow to stand twelve or more hours.
Strain, add lemon juice, and bottle.
Keep in a cool place (*not* a refrigerator).
Ready for use in 2-3 days.

Note.—The lemon is not essential, but is added to improve the flavour.

Cheese

Cheese is made from the curd of soured milk. Generally, the more quickly the milk is soured the better the quality of the cheese.

Souring the Milk

The milk may be soured for cheese-making :

1. By leaving at room temperature for 2 or 3 days. This is probably the least satisfactory method.
2. By adding rennet, 1 teaspoon to 1 pint of milk.
3. By adding junket tablets.
4. By adding a " starter "—a small quantity of already-soured milk—to the fresh milk. Keep in a warm place until set, probably for 6-8 hours.

Sour Milk Cottage Cheese

Directions : Sour the milk as quickly as possible.
When a good firm curd has formed, place in a muslin bag and hang up to allow the whey to drain away.
When the curd is firm, but moist (if left too long, it will become dry and crumbly), rub through a sieve.
Season and add any desired flavouring.

Note.—The five sections in this unit may be taken in any order and should follow the children's interests as much as possible. Teachers may wish to choose all or only some of the sections or may add further sections in which they and the children are interested.

MAKING PERFUME

At the conclusion of their activities, it is expected that children may understand that the perfume emanating from a substance results from the movement of small particles (molecules) away from the main body of the substance. During discussion it is expected that children will be encouraged to express their ideas as to the nature of the perfume. Is it separate from the substance ? Is it the same as the substance ? Is the sensation of smell just in the nose ? How does the smell get there ? Could " bits " of liquid fly through the air ? Is there water in the air ? (This could be linked with work on evaporation and condensation.) It is not necessary that the children should come to any firm conclusion about all of these questions ; in fact, the presentation of any dogmatic answer is to be deplored. A very desirable outcome of this unit is that it should encourage speculation, not suppress it.

It is also expected that children will have opportunities to develop abilities—showing greater discrimination in using the sense of smell ; devising ways of measuring the extent and the speed of the spread of the smell of various substances ; recording and organization of whatever data are collected.

Introducing the Topic

This topic may be introduced following experiences with liquids similar to the experiences outlined in *Beginning Science* under Discrimination and Classification, as a result of which household substances which possess a characteristic smell are collected. These substances may be grouped according to classifications children suggest themselves. Some children may enjoy making up, and participating in, identification games with the substances collected. They may wish to discuss questions such as : Do the smells blend ? Are some smells more powerful than others ? How far does the smell spread ? What factors affect the spread of the smell ? (During morning talk over a period of days children might care to investigate whether warming the container, for example, of Eau-de-Cologne, before opening it has any effect, and also whether the draught from an open window or a door makes any difference.)

Making Perfumes

(Perfume—from Latin *per*, through, by, by means of, + *fumare*, smoke.)

Girls will be particularly interested in perfumes and should be encouraged to bring perfumed cosmetics to school for observation and discussion. Following discussion, it may be suggested that the children should attempt to make their own perfumes. These may be liquid, cream, or dry (sachet).

During these activities, children should be encouraged to organize and record their procedure, observations, equipment, and materials. As most perfumes used in cosmetics are careful blends of many different perfumes, the children should see some value in carefully recording their activities.

If, in making a sachet, the children discover a particularly pleasant blend of odours, they will probably be interested in writing out the recipe. The same applies to liquid and cream perfumes.

Common Sources of Perfume

Flowers—rose, jasmine, orange flower, violets, lavender, tuberose, daphne.

Leaves— geranium, cypress, eucalypt (particularly the lemon-scented gum), mint, and many other garden plants.

Bark— cassia.
Wood— camphor-wood, cedar.
Roots— ginger.
Fruit— lemon, orange.
Seeds— pepper, caraway.

Animal Perfumes

Animal perfumes are strong and penetrating. Most of these will not be familiar separately ; however, they give strength and permanence to plant perfumes. It is not practical to use animal perfumes in the classroom, but the following information may form the basis for a short discussion.

Castor— from the beaver.
Civet— a fatty substance found in the civet-cat of Abyssinia.
Musk— an oily liquid from the musk-deer.
Ambergris—a waxy substance from whales.

Some of these perfumes, musk in particular, are now produced artificially.

Movement and Dissemination of Particles

At this stage some reference should be made to the problem : " What is a ' smell ' ? "

Take a well-sealed bottle of highly perfumed liquid. Allow the children to observe and discuss it. Remove the stopper and place a drop of liquid on a saucer. In a few minutes the scent should have spread throughout the room, and eventually the drop of liquid will evaporate. This is an appropriate time for questions such as :

We can smell something. Where did it come from ?
Where did it go to ? (Our noses.)
How did it get there ? (It floated through the air.)

By reference to the evaporation of the liquid the children should be able to understand that there is no mysterious thing called " a smell ". The sensation of smell is created when small particles of matter disseminate from the main body of matter and find their way into our noses. The teacher need not explain it to the children in this way. Be satisfied with their formulations and the refinements they themselves make (with a minimum of assistance from the teacher).

Perfume Recipes

If the children have understood their experiences with " smell ", the making of perfume from recipes should prove an interesting and enriching activity.

An Ancient Recipe

As it is most unlikely that the ingredients of this recipe will be availabe in Australia, it is referred to mainly as a matter of interest. See The Old Testament, Exodus, Chapter 30, verses 34, 35, and 36.

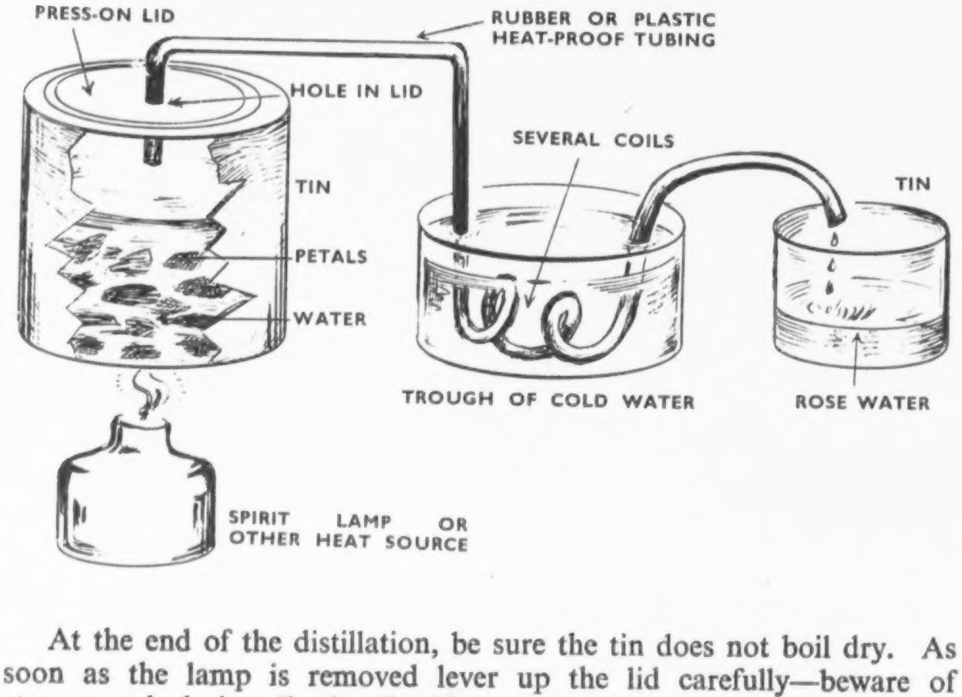
Jasmine Pomade

Take a sheet of glass (a mirror will do), coat one side with a mixture of pure beef tallow and purified lard. Cover the fats with flower petals (jasmine, tuberose, or rose are recommended) piled on one above the other. Place in a container and seal. In a few hours the fat will absorb the perfume. Add fresh petals until the pomade is fully charged with perfume. This method, called " enfleurage ", depends on the absorption of the essential oils, the perfume, by fats.

Children may wish to experiment with other fats or oils such as glycerine, lanolin, or petroleum jelly.

Rose-water

Rose-water is made by extracting the essential oil from fresh rose petals by water or steam distillation in a still. In water distillation the petals are boiled with water in the bottom of the still. In steam distillation the petals are placed on a perforated plate or in a removable cage a few inches above the water. The mixture of essential oil and steam, which is condensed and collected, is known as rose-water.


PRESS-ON LID
RUBBER OR PLASTIC HEAT-PROOF TUBING
HOLE IN LID
SEVERAL COILS
TIN
TIN
PETALS
WATER
TROUGH OF COLD WATER
ROSE WATER
SPIRIT LAMP OR OTHER HEAT SOURCE

At the end of the distillation, be sure the tin does not boil dry. As soon as the lamp is removed lever up the lid carefully—beware of steam—and drain all the liquid in the tubing into the rose-water container.

Lavender-water and Orange-flower Water (*Eau-de-Cologne*)

Use the same process as for rose-water.

Citrus Perfumes

The essential oils of citrus fruits may be extracted from the peel by expression (pressing) or rasping.

An early method uses an *écuelle,* a metal saucer with spikes on the concave surface. The fruit is rolled over the spikes and the oil runs from the skin into the saucer.

Note.—Children should not expect their perfumes to be as successful as the commercial product. Indeed, many of the perfumes children will make can be expected to smell rather unpleasantly after some time. This might provide a starting-point for a study of decay.

CHANGES OF STATE

Refer to energy unit Heating and Cooling, page 57.

ROCKS

The collection and study of rocks, which is interesting to most children of this age, provides an opportunity to give experiences around some important scientific ideas. Rocks are, to some people, an example of changelessness with time. On investigation it is found that the materials of the rocks have already existed in many forms through the geological ages, and that the rocks are now being broken down and the material put again into circulation. Close observation shows that rocks differ greatly, and the observed differences can be used to name and classify them. Rocks also provide examples of how man has adapted natural materials for his own use.

The work suggested in this unit should provide children with opportunities to :

observe and describe rocks, and to find ways of naming and classifying them ;

understand ways in which rocks could have been made, and to see that rocks are formed and broken up as part of the continuous process of change in the earth's crust ;

learn some of the uses man makes of rocks.

The emphasis in this study will vary with the locality. In some parts of the north-west of the State, for example, it may not be practicable to carry out any of the unit as set out ; in this region a discussion of the origins of limestone, the action of wind, and so on will be more worth while.

There will be some confusion between rocks and minerals. It is best for our purposes to use the term " rock " for solid consolidated material occurring in considerable quantities (this excludes sand, soil, etc.). Minerals are substances of definite chemical composition, while most rocks are mixtures ; mica is therefore a mineral and is one of the constituents of the rock, granite. Quartz is a mineral also found in granite, and sometimes in considerable deposits in pure form. For our purposes it is wise not to make a sharp distinction, and common minerals could be called " rocks ".

The most common and important rocks to study at this level are granite, basalt, scoria, obsidian (not common but very interesting), quartz, sandstone, mudstone, conglomerate, coal, limestone, marble, quartzite, and slate. Granite, basalt, scoria, obsidian, and quartz are rocks that have formed from the cooling of molten material ; sandstone, mudstone, conglomerate, and limestone have formed from sedimentary deposits ; marble, quartzite, and slate have been formed from the effects of heat and pressure on previously existing rocks.

It must be stressed that the classification of rocks into groups such as mudstone, quartz, sandstone is not the main object of this unit. *It is more appropriate for the children to group the rocks according to their own ideas.* For example :

size
shape
weight and density (light—heavy)
colour
soft—hard
rough—smooth
brittle—tough
layered—unlayered.

It can be seen that the first three classifications (size, shape, weight) are relevant to the applied number course.

Refer also to Curriculum Guide A, *Beginning Science*, page 26, Rocks and Stones.

Possible Approach

Children may be asked to bring interesting rocks to school to build up a collection. This could be added to with rocks collected in the school-ground, on an excursion, from a building contractor, or from a stonemason.

Some of the pieces brought in will have an exterior which hides the true appearance of the rock, and a fresh surface should be made. For small rocks this can be done by wrapping the rock in cloth and striking with a hammer (the cloth prevents small fragments flying about).

When a number of rocks have been collected, attention may be drawn to their similarities and differences.

The children may be asked to find out and write down all that they can about the rocks. This could be done in groups, with each group examining different rocks. This is really a test of the acuteness of children's powers of observation, and their ability to express themselves accurately. Some clues which will help them in their observations are—

(*a*) colour—some rocks are uniform, some are speckled ; sometimes a fresh surface is a different colour from the rest ;

(*b*) texture—the feel of the rock ; can separate particles be felt or are there no apparent grains ? ; some rocks are glassy ;

(*c*) density—this can only be approximate ; some rocks are noticeably denser (use this word rather than " heavier ") than others, but it is hard to estimate this unless pieces of approximately the same size are available.

Other features should also be observed. In granite, children may be able to distinguish three or four different minerals ; in basalt, small air spaces can sometimes be seen. A magnifying glass is very useful for examining the detailed structure of rocks.

When children have gained some experience in classifying the rocks according to their own ideas, they may be introduced to the more formal adult classifications. This, however, is not essential to the success of this study. The rocks can be named by reference to some books (Ellyard, *Fun with Natural Science*, *Grade* 5, Horwitz-Martin, contains some helpful information) or from a named set. A short description of the common rocks is appended to this unit.

The study of how rocks are made might proceed as follows.

Examine a piece of sandstone (or mudstone). Why is it called sandstone ? What might it have been made of ? How could sand have been transformed into sandstone ? What else would be required ?

In nature, the sand has been transformed into sandstone by pressure over millions of years. We can do something similar by using some substance—like cement—to hold the sand grains together. Mix a ½ cup of cement and 1½ cups of clean dry sand in a large can or jar. Add enough water to make a creamy mixture and pour into a plastic ice-cream container. Allow the mixture to harden for several days, then remove the container and examine the results. Conglomerate (or something like it) can be made by throwing some larger pebbles or stones into the mixture, and mudstone made by using mud or clay instead of sand.

Most children will probably know how coal has been formed, and there are many books in which they can find more about this. Limestone is formed from sediments of sea-shells or coral, and this can be seen from an examination of some specimens ; the limestone of north-west Victoria has been formed from wind-blown material from other limestone beds, and so contains no trace of sea-shells.

Examine a piece of obsidian, if available, and a piece of slag from a furnace. Both have a glassy appearance and show other signs of their once-molten state. Obsidian has formed from the very rapid cooling of molten material ; it is not possible to produce temperatures high enough to demonstrate this in the classroom. Basalt has also cooled from molten lava, but more slowly ; the small air spaces in the rock were once steam bubbles trapped as the lava cooled. Scoria contains many air spaces. Granite cooled more slowly under the surface of the earth.

Marble is formed by the melting and the cooling of limestone. Slate is formed by the effect of great pressure on mudstone. Quartzite is formed from sandstone. It is not possible to demonstrate these in the classroom, and it may be preferable to omit discussion of their origin. If children are given this information, it is important to point out the features of the rocks which provide evidence for these ideas about their origin—such as steam-bubble cavities, uniformity of texture, and distortion of fossils.

Children may be asked to identify the rocks used in local buildings and monuments. In the city of Melbourne basalt (bluestone) is used in the construction of some buildings in the older parts of the city, for example, St. Patrick's Cathedral, and for the foundations of many other buildings ; sandstone is the building material of St. Paul's Cathedral ; houses in older parts of Melbourne are often roofed with slate ; some city banks have a facade of polished granite, as does the entrance of Flinders Street Railway Station. Screenings used for making concrete and for road-metal are basalt. Limestone is used in the making of cement. In some country areas, local rock is quarried and used in buildings—for example, Mt. Gambier stone and bluestone.

Children may wish to include bricks, tiles, and concrete in the collection. The similarities of and the differences between these materials and rocks that occur naturally might provide a fruitful topic for discussion. This offers an opportunity to link the topic with social studies, and also provides a lead into the units Plaster and Cement, Fire, and Heating and Cooling.

A Description of Some Common Rocks

Basalt (bluestone) is a blue-grey or grey rock, fine-grained, and often contains small air spaces.

Scoria is a light " spongy " rock, often ash-coloured.

Granite is a speckled black and white (sometimes pink) rock, with at least three minerals clearly visible.

Quartz is generally milky-white, sometimes with orange or brown patches, and with no discernible granulation.

Sandstone is a coarse-grained, generally yellowish, rock.

Mudstone is a fine-grained, soft, generally grey, rock.

Shale is similar to mudstone, but harder.

Conglomerate is composed of pebbles cemented together with finer material.

Limestone is white or grey, fine-grained, and often contains shell markings and patches of different colour.

Marble is white and uniform in appearance.

Slate is hard, grey, and layered.

Obsidian is a volcanic glass, black or greenish-black, transparent in very thin layers, and quite smooth with no crystalline structure.

WEARING AWAY THE EARTH

Perhaps this unit could better be called Random Experiences with Physical Change since it is not particularly concerned with drawing a rigid conclusion about the nature of the earth's crust. There is a thread running through the activities outlined below ; they all illustrate processes that are at work changing the earth's surface, but the main concern is with somewhat less important ideas. The experiences should help lay the foundation for the very important idea that change is a constant feature in nature.

The immediate aims include the carrying out of some enjoyable science activities, practice in asking questions and carrying out experiments and observations to answer them, and seeing some of the ways in which natural processes can be understood by experiment.

Opportunities should arise to link this unit with social studies.

Suggested Activities

With a hose, a jet of water may be directed onto a bare earth surface or a mound of earth. The children may be asked to observe and describe what has happened. Where has the soil carried by the water gone ? This may lead to discussion about rivers, creeks, lakes, and the sea. Do rivers carry soil and other materials ? Where are these materials dropped ?

The children may experiment with jets of water on the bare earth and on grassed earth ; on clay, gravel, and sand ; and compare the results. If playground conditions are suitable, it might be possible to observe the same sort of thing on a wet day.

What sort of materials would be carried by a big river or by a small creek, or by a fast-flowing stream compared with a slow-moving stream ? Could a small creek move large rocks ? One way to find answers to some of these questions is to put some gravel, sand, silt, and clay into jars of water and to swirl them about. When the water is moving, a lot of material remains suspended, and the gravel rolls around the bottom. When the water is still, most of the material settles, but some remains suspended. Children may be asked to observe which settles first, and to note the layers formed. Perhaps an account of the experiment can be recorded, partly in pictorial form.

A collection of smooth, rounded water-worn stones may be started. The stones are not really water-worn ; as they are carried along by a stream the stones rub against each other and on the rocky bottom of the stream. Small pieces are knocked off in the process. Compare this with the gemstone-tumbling process. Children can simulate this by rubbing pieces of sandstone together. What do the pieces that break off look like ?

Temperature changes also cause the breaking-up of rocks. In inland regions low night temperatures contrast with high day temperatures. Some glass marbles may be heated in water in an old saucepan over a spirit burner, and then dropped into cold water (a pea strainer could be used to remove the marbles from the hot water). The marbles could be compared with others that have not been treated this way. Small pieces of rock could also be used—granite is particularly good. The reverse process could also be investigated. That is, cold marbles or rocks from a refrigerator (or the school-ground on a frosty morning) could be dropped into hot water.

Accurate observation and telling or writing about the observations are desirable.

Note.—Because of the danger involved in handling hot water, this part of the experiment should be done by the teacher. The children should learn the need to handle fire and hot things carefully. These activities provide another opportunity to teach safety practices.

A screw-top bottle may be filled with water and sealed with the screw top. The bottle can then be wrapped in a cloth and placed in the freezing compartment of a refrigerator. This can be done at home, or during the school day if there is a school refrigerator. The children may be asked to explain what has happened, and why. (The water takes up more space when it freezes.)

The class might be asked to think about what happens when water in the cracks of rocks freezes. Perhaps this can be tried by soaking pieces of porous rock in water and then freezing.

PART II

ENERGY

PART II : ENERGY

For a full understanding of the material that follows it is essential to refer to the introductory remarks on energy in the *Course of Study for Primary Schools, Science.*

FIRE

Fires and flames seem to be perennially interesting to mankind—especially, it might be said, to men. Witness the pleasure men get through burning rubbish in the back yard, or watching a bonfire. Perhaps this is a survival of primitive man's interest in a mysterious, awe-inspiring phenomenon with a frightening potential for harm. In a fire, matter is changed in shape and form, and heat and light are also produced.

Children will think about energy and fire in their own way, but their ideas of change and of bringing about change should develop further as a result of their activities at both junior and senior levels. Activities for the junior level are likely to be diverse and closely related to work in other topics in science or social studies. Some suggestions are given in this unit for the following topics :

Kindling Fires
Fires and Fuels
Putting out Fires
Associated Topics.

A Note about Safety

Activities suggested here should be used to develop desirable safety attitudes. These attitudes are likely to be undermined if the teacher's classroom organization does not reflect the same attitude to safety. No hard and fast rules can be stated here, since measures to be adopted will depend on the class, its size, and the maturity of the individual children. Points that teachers should consider include the following :

Materials To Be Used. Some heat sources such as candles and solid-fuel tablets may be used by children ; other heat sources such as liquid gas and methylated spirits should be for the exclusive use of the teacher, with the children as onlookers.

Size of Groups. There is no optimum size of a group. It may consist of one or two individuals or of the whole class. A large number of groups should *not* work with simple heat sources such as candles in a limited area.

Place for Work. If the classroom space is cramped, the shelter-shed may prove more satisfactory. On the other hand there will be times when the classroom is perfectly satisfactory. Draught and wind conditions should be considered. Metal trays or asbestos mats may be necessary to shield the flames from draughts.

In general, work should be done with the smallest heat source that is useful and with small quantities of materials. Of course, *the teacher* *should be present at all times when inflammable materials are being used, and children should be warned about conducting experiments of this nature away from the school.*

Kindling Fires

Activities may arise from discussion about cave-men or aborigines and the means they used to satisfy their needs for food, shelter, and warmth.

Children may wish to emulate primitive people by attempting to produce fire as they did, by rubbing sticks together. Children invariably fail although some heat is generated, but the children's attempts to produce fire could lead profitably to a discussion of why they failed and how their failures might be overcome, at least at a theoretical level. The children may not always fail.

Making Sparks

In one class the children tried to make fire and failed. Then one day a boy announced that the " tinder " being used was not dry enough. His father, who had been a science teacher before he emigrated to Australia, had told the boy that cotton-wool, if soaked in potassium permanganate (Condy's crystals) and then dried thoroughly, would be a suitable material for tinder. No one seemed to be quite clear as to why this should be so, but it was agreed that his advice should be followed. (Teachers may be interested to know that the residue of potassium permanganate on the cotton-wool provides a source of oxygen which enables the spark to be kindled more readily.) Next day a clean file was struck against a suitable stone and sparks were produced, but no flame. While the class continued with their normal work the teacher and several children continued working with the tinder, the file, and the stone. After half an hour they were successful, and a tiny flame was carried to the fire-place where a roaring blaze was soon produced.

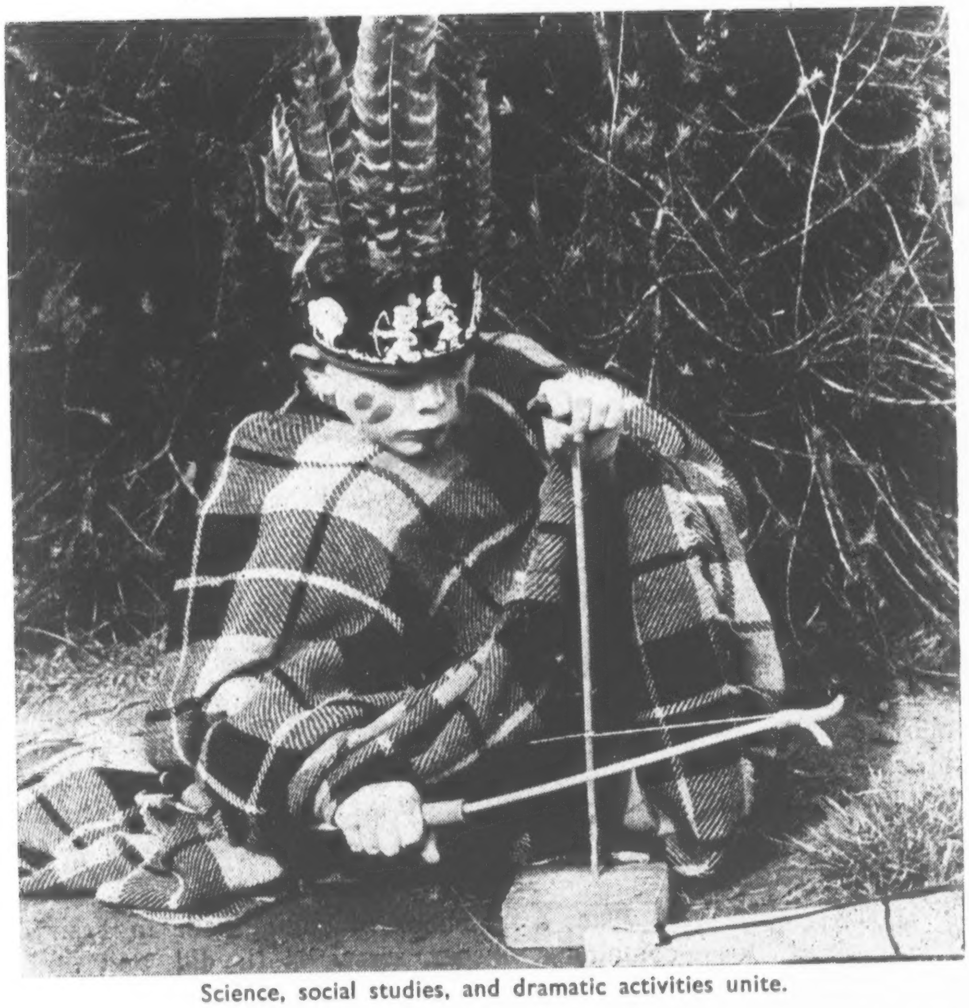
Somewhat quicker results might have been produced with a grindstone. Materials other than cotton-wool could have been used, including linen " cooked " in an oven until it began to char.

Rubbing Sticks Together

In another class, where children had rubbed sticks together unsuccessfully, it was decided that failure was due to the fact that the sticks had not been rubbed quickly enough. One child suggested that a drill could be used to turn one stick rapidly. Next day a hand-drill, a meat skewer, and a piece of soft wood were brought ; the children's efforts began anew, and a fire was at length produced. The task can be made easier if a depression into which the skewer will fit is made in the piece of soft wood ; if the children do not meet with success they may be assisted by placing several match-heads in the hole ; a small quantity of sulphur (obtainable from the chemist) could also be introduced into the hole ; pieces of wood could also be warmed and dried in an oven beforehand.

Using a Burning Glass

Given the right weather, a magnifying glass, some paper, and some tinder, it is not hard to light a fire. The magnifying glass is not essential.



Science, social studies, and dramatic activities unite.

In one class, a bottle of water was successfully substituted for a lens. Even better is an old-fashioned water carafe. There are records of a number of occasions where sunlight passing through glass has caused an accidental fire ; bushfires have started from bottles left in grass or scrub at picnic grounds.

Fires and Fuels

Although some small-scale activities might be possible in the classroom, more satisfying work can be done out of doors when weather conditions are suitable. Activities might begin when the question of the best material for fire-making is being discussed. The children may decide that some small fire-places will be necessary, and these could be made from a few bricks.

Tests could be carried out to compare green twigs, dry twigs, soft wood, hardwood, briquettes, and black coal.

An activity such as this can provide a good stimulus for written work, which might vary from factual descriptions of close observations to writing which shows a more personal, emotional response.

In the classroom the activity could lead to further investigation of inflammable and non-inflammable materials that can be collected and tested. Materials used might include cork, aluminium foil, balsa-wood slivers, slivers or chips of other types of wood, small pieces of plastic material skewered on a straightened paper-clip, insulating fibre, steel wool, leaves (eucalypt, tea-tree, various deciduous trees), wet materials and dry materials, and cloth.

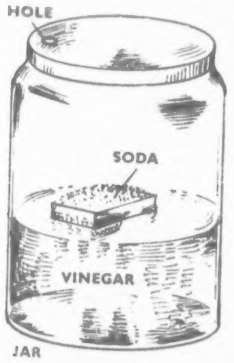
It must be emphasized that only small samples and a small flame (candle) should be used.

Further work could be done using small flames and jars. A jar should be held over a candle-flame without completely covering the flame, and changes in the behaviour of the flame noted. *Beginning Science* (see the section Inanimate Materials) contains some useful suggestions for starting-points.

Putting Out Fires

Activities such as those noted above may lead to a discussion of ways of extinguishing fires. These could include smothering flames by using water, sand, a blanket, a piece of wood, a cement sheet, detergent suds, or foam from a fire-extinguisher.

A fire-extinguisher of the most common type contains acid and soda. Children may be interested in making a fire-extinguisher and this they could do, using vinegar and baking soda. An activity of this type would follow naturally from conversations with the fireman who visits the school to check extinguishers. Encourage children to attempt to make their own fire-extinguishers. The diagram below illustrates a very simple one.



Place a matchbox of baking soda in a jar containing vinegar, screw on the lid, and tip the jar to one side. Foam and carbon dioxide should come out of the hole and extinguish a burning candle or a fire kindler. There is no need to talk about carbon dioxide.

Associated Topics

As with other units, the topic Fire should not be seen as a closed topic. Other interests can and should be followed up. If a science study evolves into social studies, this is no cause for worry if interest is maintained and associated with some intellectual " rigour " appropriate to the level at which children are capable of operating. Some of these interests might be :

Fire-walking. Discussion and reading on this topic might be associated with general studies of people and practices in other countries.

Fire-places and Chimneys. Children may wish to make chimneys for their small candle-flames. Sheet-metal tube chimneys and cardboard fire-places may be useful in emphasizing the role of real-life chimneys and fire-places in creating up-draughts.

This could lead to an investigation of how fire-places and chimneys are made. Most builders would agree that these things are not as simple as they may appear at first.

An extract from Kingsley's *The Water Babies* or a description of the work of boy chimney-sweeps in the early nineteenth century might also be appropriate as science merges into social studies.

Fire-brigades. An excursion to a nearby fire station might be worth while. It may lead to investigations of the work of other organizations, including the police force, hospitals, the local council, the customs department, and others.

The Great Fire of London. An account of this would be interesting to children. It may lead to a consideration of other fires and great disasters such as the Tokyo earthquake and fire, the destruction of Pompeii, Krakatoa, tidal waves, plagues, bush-fires, and so on.

Interest themes such as those indicated above play a powerful role in galvanizing children into activity. Experience has shown that children will work tirelessly on making class books, group pictures, and models on such subjects. The intellectual and the social values of such work cannot be over-emphasized.

HEATING AND COOLING

At the conclusion of this series of activities children should be able to—

demonstrate their knowledge of different ways of producing heat ;

give some account of the effects of heat on various materials, causing melting and evaporation, chemical change, and growth ;

give some examples of the uses of heat in " doing things ".

Children should also demonstrate in their work some development in the ability to—

isolate factors through the design of " control " experiments ;

make accurate observations of change, noting the time taken (where this is appropriate) ;

organize information obtained in the form of tables and graphs ;

write clear reports of the activities undertaken.

The work is also designed to stimulate change in children's attitudes, which would be shown by a growing readiness to ask questions, to sense problems, and to criticize experimental methods used.

It is expected that work will arise naturally, particularly if it has been preceded by activities based on the unit Fire. Activities involving change in the weather, informal work with thermometers, work with electricity (see Batteries, Bulbs, and Wires), the feel of corrugated iron or other metals left in the hot sun, and so on indicate that many occurrences can serve to arouse interest in this field. What follows is not meant to represent an approved sequence of activities, but simply to suggest an abbreviated collection of investigations that may result from the discussions and the observations that occur. It may be preferable to start from the children's interests rather than from the first section outlined below.

Making Things Hot

When interest has been aroused by observations of how a certain object became hot, children may like to investigate alternative methods of heating. These may include—

the sun—heat from this source can be concentrated by using a magnifying glass ;
burning ;
movement—rubbing things together, hands, a drill in wood, sand-papering, striking a match on a box, bending wire or other thin metal ;
volcanoes—that is, the interior of the earth ;
electricity.

Children may care to compare heat loss from a variety of objects, which should lead to some understanding of the fact that the rate of heating or cooling of an object is partly dependent on the nature and the quantity of matter involved. (Children should not be expected to express this idea in these terms.)

They should gain an intuitive grasp of the idea, however, by—

placing an empty tin and a tin full of water in the sun (or on a heater) and feeling the outer surface after some time ;
heating a tin and a brick, then noting how long each takes to cool down. To heat them, place in the sun for some hours or, alternatively, place on a heater until the brick feels as hot to the touch as the tin.

Other activities may simply involve children in attempts to " make things hot " by heating, either in the sun, on a heater, or above a simple heat source such as a candle or a solid-fuel tablet (obtainable from hardware stores). Objects heated should be chosen from categories such as heavy, light, solid, and hollow.

Doing Work with Heat

The idea that heat is a form of energy may be out of place at this level as an explicit statement, and certainly it should not be equated in any formal way with work as it is defined by physicists. On the other hand it is desirable that experiences should lead to a realization that heat " makes things happen ", to use a phrase that indicates the probable line of thinking at this level.

Many of the activities already suggested are likely to lead to this idea, particularly those involving change of state. Concentrating the sun's rays with a magnifying glass to start a fire is another dramatic example. Some suggestions for additional activities follow.

Watching a Donkey Engine at work, preferably attached to some child-constructed toy machine. A full-scale investigation of this and other steam-engines may be left for children in the upper school.

Cooking. The section Interactions and Change in *Beginning Science* contains an account of a cooking activity, and this indicates the early development of such a topic. Using their tin-lid crucibles, children at the junior level may care to make further observations of the chemical changes brought about as foods are heated. Many children associate charring with direct contact with a flame rather than with heat. Small cubes of foods, including onion, bread, meat, and fruit, are suitable for use in this activity.

Washing. A comparison of the efficiency of hot soapy water and cold soapy water in washing dirty cloths.

Making Things Grow. References to this activity will be found in the Life section of this guide. In brief, children could study the rates of germination and growth of seeds and plants in different environments, varying from a position close to a heater to the inside of a refrigerator.

Causing Spoilage of Perishable Materials. Milk and other foods should be observed and compared when left in warm conditions and in a refrigerator.

Preventing Spoilage. Sealed jars of boiled and unboiled broth should be left and inspected over a period of several weeks.

Melting and Evaporation

Children in Grades I and II will have had some experience with solids, liquids, and gases. They will know, either from school or out-of-school activities, that water can be changed into a solid or a gas by cooling or heating sufficiently. (If there is doubt about children's understanding of this principle, some ice should be obtained. Let the children watch the ice melt at room temperature, and then heat and boil the water.) This series of activities is designed in order to extend this idea, so that children realize that the terms " solid ", " liquid ", or " gas " only apply to a particular substance at ordinary temperatures. Substances can exist in any of these forms, given certain conditions. Children should also discover that liquids change to gases at ordinary temperatures, generally at a fairly slow rate, and that heat has something to do with the change.

The experiences outlined below will provide children with some of the background necessary for a later understanding of the molecular theory. Briefly, according to this theory, matter consists of small particles. In a solid the particles are in constant motion, vibrating about a certain fixed position ; they cannot move about freely. If heat is applied, the particles acquire more energy and therefore vibrate over a wider amplitude ; at a certain temperature they break free from their position and can move about within the substance, although the particles are still quite closely packed. The substance is now a liquid. If more heat is supplied, the particles move faster and some escape the liquid altogether ; that is, evaporation occurs. In a gas the particles are a long way apart and move rapidly ; a gas occupies the whole space available to it, and the rapid movement of the particles is shown by the fact that if a bottle of ammonia is opened at one end of a room, the particles can soon be detected at the other end. These ideas should not be put to the children ; experience is the important thing at this stage.

The activities in this unit, apart from providing the basis for ideas of the molecular theory, provide many problems which can only be solved by sorting out factors and designing controlled experiments and observations.

Materials

Heaters. Although spirit burners are useful in the upper primary school and may be suitable under certain conditions for use at this level, safer sources of heat are candles and the solid-fuel tablets referred to in the previous section.

Shoe-polish tins and lids, to be supported on bricks and used as crucibles.

String.

Plastic pill tubes.

Substances that can be melted or at least softened over the heaters children use : wax crayons, candle wax, plasticine, solder, butter, chocolate, milk-bottle tops (aluminium), resin, road bitumen, sugar, moth-balls, a variety of plastics, rubber.

Other substances that will not melt easily, such as steel and stones, would also be useful for contrast.

Melting

The first activities involve trying to melt various substances, that is, to convert some solids to liquids. Perhaps a problem may originate in a social studies discussion—Why doesn't the ice at the South Pole melt ? If the Earth was a bit colder, what would it look like ? On the other hand, if it was hotter what would it be like ? Would other things besides the ice melt ? What sort of things melt on a very hot day ? (Chocolate, butter, etc.) Discuss what conditions might be like on a planet closer to the sun.

Discussion of flames may develop during work on the unit Fire, and this may lead to a consideration of what the Earth would be like if the temperature on a hot day was as hot as the flame. Discuss what things might be liquid. The next stage is to try some experiments. Children can do this in groups, or one or two children in turn can do the experiments in front of the class. Use the boot-polish tins or lids to hold the substance being heated. Encourage the children to make suggestions as to what they think might be melted. Substances like plasticine, candle wax, crayon, solder, butter, chocolate, aluminium (several clean milk-bottle tops twisted together), resin (the type sometimes used in soldering), road bitumen, sugar (heat gently to begin with), *crêpe* rubber, as well as substances like pieces of steel, stone, etc., which will not melt at this temperature, should be kept on hand.

Something special can be done with moth-balls. When these are heated, some liquid will be formed but probably not very much. A white vapour will be given off. Discuss how we could convert the vapour back to the solid or the liquid. By comparison with the conversion of steam to water, most children will see that the vapour should be collected by placing a cool surface—another boot-polish tin perhaps—in the path of the vapour. Crystals of the solid will be formed on it, showing that a gas can be converted directly to a solid. The recorded work from the above activities could be in the form of charts listing the names of the substances, together with the information as to whether or not they melted. It is a good idea to record results as soon as each little experiment is completed. *The important thing is not the particular result but the overall idea that many substances will melt when heated.*

Rapid Cooling

This can be achieved by pouring molten material into cold water. Children enjoy comparing the shapes formed by the solidifying material, and this may lead to an investigation of the practical applications of the process in moulding. Discuss the shapes that could be made from liquid materials. Find examples of moulded objects in the room or elsewhere, for example, plastic electrical switches, Biro pen parts, taps, brass fittings under sinks, plastic sandals, metal parts of desks, cast-iron stove parts, chocolate. Perhaps this activity will lead to an attempt by the class to make something from molten material by themselves. The main problem will be finding a suitable mould.

Something that could be attempted would be to make a coloured candle from candle wax, a piece of wax crayon, and a length of string. The problem might be posed : " Given this container of wax, this piece of coloured wax crayon, and a piece of string, how would you make a coloured candle ? " A possible mould in this case would be a plastic pill tube ; the solidified candle can be removed from the mould by pouring hot water over the mould, so that the outside layer remelts. There will be some problems in this project, but most can be solved by the children working and talking together.

Evaporation

This second series of activities, which can follow immediately or can be carried out at any other convenient time, concerns the change from liquid to gas or vapour. Better results will be obtained in warm weather.

A problem might arise after a shower of rain. Where has the water on the footpath or the tennis-court or in a puddle gone ? Or it might be found that the aquarium needs topping up with water. Why is this necessary ?

Most children will know—or think they know—the answer to these questions. It is necessary for them to test out their own theories, to find out whether they can prove or disprove their opinions and, in general, to expand the scope of the explanation offered.

A possible answer will be that " the sun dried up the water " (or caused it to evaporate). It is suggested that the words " evaporate " and " evaporation " should be used. A discussion could follow on how this is known. Would the water dry up if there were no sun ? Someone, it is hoped, will suggest an experiment to find out. Perhaps some water can be put in a shady place and some in a sunny position. Let the children organize things from here ; encourage the criticism of each other's plans. Some will probably put different quantities of water in each container, or use containers of various shapes. If this does not lead to criticism by other children, the teacher should ask questions to stimulate this. " Will it make any difference if one container has more water than another ? " " Which would take longer to evaporate ? "

The experiment requires two equal quantities of water in similar containers, one in a shaded place and one in the open or exposed to the sun. If a small quantity of water is used, results will appear more quickly.

Another explanation may be that " the water goes into the air ". If this suggestion is made during discussion, the children should be able to suggest an experiment to test this. One idea is to use equal quantities of water in a bottle and in a saucer, so that one has more surface area exposed to the air than the other. In this case, the two containers should be exposed equally to sunlight. Again it is important that the children design the experiments themselves, in the course of discussion and with the help of some questions from the teacher.

It may be said that "the wind dries the water". If there is an electric fan to create a wind, the class will be able to design an experiment to test this—for example, by putting a quantity of water in front of the fan and an equal quantity away from the fan, in otherwise similar conditions.

This experiment may be followed up with a discussion on the best conditions for drying clothes. If the children are keen they might even like to experiment with different pieces of cloth under various conditions.

Remember that in the above activities the stress is not on the actual results, although these are important to the children and they will probably remember them, but on the use of control experiments. Each experiment requires two set-ups, alike in all respects except one. This enables us to determine the effect of the variable, the condition that differs between the two set-ups.

Several links with other aspects of science have been suggested above. It should be apparent that there are many more, and it may happen that work on heat will extend throughout the year. This is all to the good if it emphasizes the essential unity of science.

MAGNETS

Magnets hold a fascination for children of all ages. Activities with magnets are simple, interesting, and suitable for either individual or group work.

The children should be encouraged to handle the magnets freely. Their experiences will give them a better knowledge of magnetic force, forces acting at a distance, and of attraction and repulsion. It is not desirable, however, to attempt to teach children these things; the aim should be to provide experiences which give a background for work in later years, and at the same time develop the skills discussed in Developing Abilities.

Before commencing this unit, refer to the section on magnets in *Beginning Science* under the heading Energy and Forces. It is suggested that these activities be repeated, and that work in this unit should arise as an extension of the earlier activities. Children at this level can be expected to show more purpose in their planning, experimenting, and recording.

Some work with compasses might interest the children. Most children enjoy "hunt the treasure" games in which a child is given a compass and attempts to find the treasure by following a set of instructions, for example, four paces (yards or feet) north, five west, eight south. This can be regarded as a combination of science, applied number, and language work.

Magnets can also be used in other units such as Separating Materials; Rocks; Batteries, Bulbs, and Wires; and Moving.

This topic is developed further in Part C—*Branching Out*.

BATTERIES, BULBS, AND WIRES

At the end of these activities it is expected that children should—

- be able to demonstrate or discuss, in language suited to their level of understanding, a variety of ways in which the energy stored in a dry cell can be used ;
- be able to demonstrate some understanding of the nature of a circuit ;
- be aware that the flow of energy is dependent on the conductivity of the materials in the circuit ;
- be aware that there is some connexion between electricity and magnetism ;
- have an improved ability to manipulate equipment.

It is also expected that opportunities should arise for children to develop the ability to organize data (conductors, non-conductors), to make inferences (nature of a circuit), to test ideas (possible arrangements for a circuit), and to measure (length of cell-life).

Finally, it is hoped that children will show a readiness to suggest questions, to provide explanations, and to form conclusions on the basis of evidence collected.

Interest in this topic may develop in a number of ways, but it can be assisted if a collection of materials is begun and placed where it can be handled freely by children.

Materials

Dry cells—torch cells (batteries), both single and double, and, if available, a larger dry-cell battery.

Globes—from torches, from bicycle lamps, and from car lights.

Wire—single and multiple strand ; copper, steel, brass picture wire, plastic-covered wire, bare wire.

Sundry materials—milk-bottle tops, steel wool, aluminium and lead strips, pieces of plastic, pencil lead, hairpins, thick bolts, salt, sugar, water, honey. These materials are not prescriptive ; the list is simply meant to show that a wide variety of materials is desirable.

In most cases the availability of the material tends to stimulate activity without the necessity of teacher intervention, except to help with organization and to provide suggestions when the need for these becomes evident.

Preliminary Observations

A suggestion to children that they should find out all they can about globes and cells, the parts of torches, and the length of life of dry cells may be sufficient to initiate close observation. Work could be done by small groups taking notes and contributing their findings to a general class discussion.

If spent cells are available, they should be cut open and the contents classified, perhaps as black " stuff " (chemical), a rod " like a thick pencil lead ", brass caps, a soft whitish metal. The children could be told that the metal is zinc and the rod is carbon.

Another investigation might involve an examination of the part played by the switch in the torch.

Children may suggest methods of determining the relative length of life of dry cells. Probably the most popular method will involve noting the length of time a globe will burn when attached to a dry cell. This need not be an expensive investigation if very small dry cells are used. Fresh cells are needed, but it would be better if the necessity for these was not alluded to directly by the teacher. There is an opportunity here for abilities in experimental method to be developed if the situation is handled with skill and imagination.

Making Circuits

It is more than likely that investigations will arise naturally out of discussion, particularly of the workings of a torch. Children might like to attempt to make their own torches from dry cells, globes, and wire, and this should lead to some understanding of the need for a circuit to be completed.

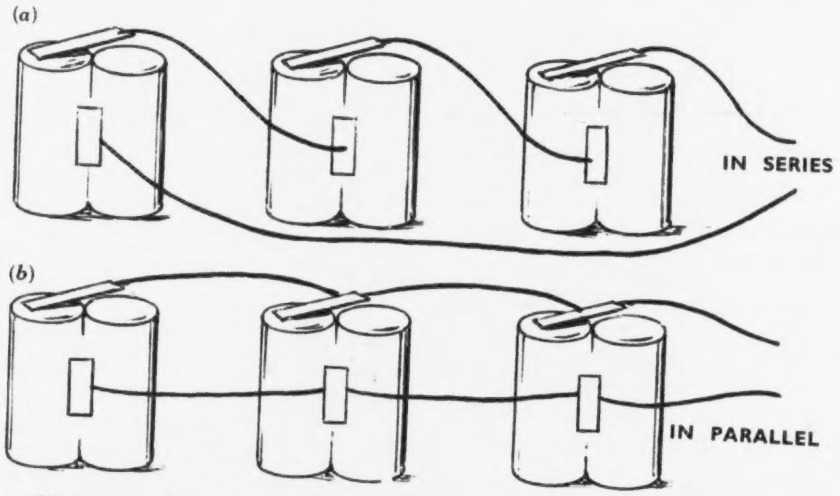
Interested children might like to go on and design their own switches and to make more complicated circuits using—

(*a*) several globes,

(*b*) several dry cells wired in different ways.

Children will need to invent methods of holding globes in place if the cheap sockets sold by city electrical-parts retailers are not available. Most children are able to devise effective substitutes from wooden spring-loaded clothes pegs, which can be attached to plywood bases.

It is not necessary to use terms such as " in series " or " in parallel ". No doubt children will discover that dry cells (particularly in the double torch batteries, with long brass terminals) can be wired together in two ways :



Note.—A *battery* is made when *cells* are wired together.

In the first case the three 3-volt batteries produce a total of 9 volts. In the second case the voltage is not increased. Children might like to experiment by wiring one or more 1½-volt globes into each system. A 1½-volt globe would burn out rapidly in the first system.

It must be emphasized that these are not facts to be taught. It is preferable that children should be encouraged to organize their own findings and report them to the class. Children's developing abilities can be evaluated by noting the strategies they employ in organizing their activities and in setting out the results.

Conductors

The availability of the variety of materials mentioned at the beginning of this unit should ensure that activities in this area arise naturally. No doubt children's early efforts will be clumsy. They may attempt to hold a dry cell, wires, a globe, and the material to be tested (perhaps a comb) in their hands. If so, encourage them to make a " current tester ". It is not necessary to show children how to do this. It is the sort of creative problem that provides another opportunity to develop abilities that are valuable in science. Note also the methods children use to organize their results—whether they use a written account of their work or use a carefully constructed table of results in conjunction with a written explanation. Finally, note whether or not children seem content to present the tabulated results, or whether they go further and put forward a conclusion consistent with the tabulated results.

EXPERIENCES WITH LIGHT

There are a number of starting-points for this work. Children may become interested in light after being sunburnt. Reflections on the ceiling, rainbows caused by sunlight passing through the fish-tank, and experiences in art are other possibilities. Where there appear to be a number of promising lines to follow up, the work lends itself to group activity. One group may experiment on living things, another may work on colour mixing, and another on the features of various instruments such as magnifying glasses, toy telescopes and binoculars, and torches.

Some Objectives at This Level

To give practice in observation, in designing experiments and carrying them out, and in expressing ideas with clarity.

After their experiences, children should have more developed ideas in the following areas :

Energy. Light can bring about change. At this level children should not be bothered with definitions such as " energy is a capacity for doing work ". The idea of light causing change may, however, become explicit.

The Nature of Light. White light can be broken into colours. Mixing colours produces other colours.

Light Rays. These can be bent and concentrated. Many of the experiences will be of a very general nature, providing a background for later work.

Energy

Here the aim is to note how light brings about change. In summer, children are aware of the sun as the cause of sunburn. Here the point is that light has caused a change in the skin, and this may lead children to consider how light changes other things. The effect of light withdrawal can be included in this study.

Children might be asked to suggest what effects the cutting-off of light would have on human skin, and how this could be observed. One method would be for volunteers to wear sticking-plaster patches for a number of days and to observe any changes when they are removed.

How else could changes be observed ? Children may suggest growing plants in light and darker places, or placing a bag over a patch of lawn for a time. Other activities might include moving a fish-tank and watching for changes in the growth of algae in it. Sunflowers and marigolds follow the sun during the day, and these should be grown if conditions permit.

If ants, worms, or lizards are being kept in the classroom, the effect of putting them in sunlight or in shade, and of putting red cellophane over their containers, could also be noted. One difficulty here is that light and heat frequently go together, and any change in behaviour by the animals may be due to the effect of heat, not light. If this problem arises, ask the children what could be used as a source of " cooler " light instead of the sun. A light globe might be suitable.

Lights and Colours

In *Beginning Science* some introductory experiences in this area were mentioned. In Grades III and IV, experiences could be similar but with more emphasis on the planning of activities and the ordering and measuring of results.

If two torches are available, pieces of blue cellophane and yellow cellophane should be attached so that blue beams of light and yellow beams of light can be directed onto a whole surface. Children should note what happens when the beams are directed at the same spot. Similar effects will be noted when children make coloured spectacles using cellophane of different colours. Spectacles can be made easily from a cardboard rectangle with two pieces cut out about an inch apart. Coloured cellophane can then be placed over the holes. Encourage the children to list their findings, for example, blue + yellow = green ; blue + red = violet ; red + yellow = orange.

Results obtained with cellophane could be duplicated and checked against results obtained from oil pastels and water paints.

This work might develop further and some children might like to mix powder colours systematically. They would need to decide on a standard measure (perhaps a level salt spoon and a given quantity of water). In this way they could make colour ladders using one colour or a mixture of colours in graded quantities.

Children may find that the results obtained while working with pigments and coloured cellophane may differ. This is due to the fact that the pigments absorb certain colours. This need only be noted as a puzzling irregularity and emphasizes the necessity to be cautious in making forecasts.

Bending Light Rays

Work in this area should be informal, using the magnifying glasses, lenses, old spectacles, binoculars, and telescopes that children bring along.

Encourage them to talk about what they see and do, and let them write about this. Such work could provide a valuable background for more formal work at the senior level.

MAKING SOUNDS

This unit should provide children with opportunities to—

- design, make, and use simple sound-producing instruments ;
- design and carry out experiments ;
- make careful observations, classify sounds and instruments, make simple inferences, and communicate results.

At the conclusion of the activities children should—

- be able to suggest methods of producing sounds from various objects ;
- be able to construct simple percussion, wind, plucking, and rubbing instruments ;

be able to demonstrate ways of changing the pitch of simple sound-producing instruments ;

have a greater understanding of the connexion between sound and movement (vibration) ;

have a greater understanding of how the voice is produced.

Introducing the Topic

Interest in sounds is common among children, and this interest may be heightened through experiences with musical instruments, toys which produce sounds, and noises made by machinery (drills, fans, motors, etc.). Once the initial interest has been created, simple games help to give children some idea of the variety of sounds. For example :

Identifying Sounds. The children listen, with eyes closed, while a child makes a sound (bouncing a tennis-ball ; writing on the chalkboard ; whistling). The class attempts to identify the sound.

Tape-recorded sounds may also be used.

Making Sounds. One child may be asked to make a sound. Then other children may take turns at making similar sounds. Suppose the first child made a sound by clapping his hands. Other children might then make sounds by stamping, slapping, etc. That is, they all make sounds by *striking*. Similarly, many sounds may be made by plucking, rubbing, blowing, and bending. Children may not use all of these ways of making sounds at this stage ; the teacher is advised to allow the children to make their own classifications in their own time.

Describing Sounds. Children attempt to describe a sound in one word, for example, banging, tinkling, ringing, buzzing, loud, soft, high, low, short, sharp, long.

It is sufficient at this stage if the children are aware that a great variety of sounds may be produced in a number of ways.

Collecting and Making Sound-producing Instruments

Start a collection of sound-producing instruments. Children will probably bring along a variety of musical instruments and toys. Of greater value are the simple instruments the children make themselves. Children may be left to their own resources to make some of these instruments. A collection of suitable materials should be made available and the children given the opportunity to construct simple instruments from these. Suitable materials would be bottle tops, nails, boards, rods ; a can with a lid, dried peas ; cans with ends cut out, rubber from balloons, string ; teaspoons, pieces of string of varying lengths ; comb, tissue-paper ; fresh gum-leaves ; thin wooden slats (rulers), cords ; cigar boxes, rubber bands ; jars, bottles, tubes ; cardboard.

Teachers and children should be able to suggest other suitable materials.

Classifying Sounds

By this stage the children should have a wide range of instruments, and they may now attempt to classify these into particular groups. The instruments may be classified according to—

- sound made by bending, striking, plucking, blowing, or rubbing ;
- the volume of sound produced ;
- the pitch (high, medium, low) ;
- the type of sound produced (melodious or non-melodious) ;
- the duration of sound.

Children should be encouraged to suggest classifications themselves. The above list is only intended as an example of the type of classifications that could be expected.

Note.—This section provides opportunity for development of observation and classification skills (see Developing Abilities).

Is there some common characteristic in each case when sound is produced? From observation during the foregoing activities, the children may have realized that sound is produced by movement or vibration, usually caused by blowing, plucking, rubbing, or striking the instrument, and that if there is no movement there is no sound. Whether the children have expressed this idea or not, the activities that follow should serve to demonstrate or confirm the idea. It is hoped that the children will attempt, *with a minimum of teacher assistance*, to carry out the experiments themselves, carefully observe the results, keep a careful record of their observations, attempt to make a valid inference from the material available, and suggest further experiments to test their ideas.

At no time should the teacher regard this as a list of steps to be followed by the whole class. The children should be permitted to organize the work in their own way as far as possible.

Sample Activities

Striking

- Strike a tuning fork. Look carefully at the prongs. Place the fork gently against your cheek. Dip the fork in a glass of water.
- Place grains of rice on a drum. Strike the drum.
- Put some water in a wine glass. Tap the glass gently with a spoon.

Rubbing

- If a violin is available, allow the children to feel the vibration through the string or the chest (resonance box) as the violin is bowed.
- Partly fill a wine glass with water. Wet the finger and rub around the lip of the glass. A continuous high-pitched sound will be heard. Observe the vibration of the water.

Plucking

- Stretch a rubber band over a cigar box. Pluck the rubber band.
- Pluck elastic, string, springs, etc.
- Pluck the strings of musical instruments such as violins, guitars, and auto-harps.

Blowing

Blow onto tissue-paper and comb.

Some children may be able to make " gum-leaf " music.

Blow into bottles, bicycle pumps, the cupped hands.

Blow through the reeds from instruments such as the clarinet and the oboe.

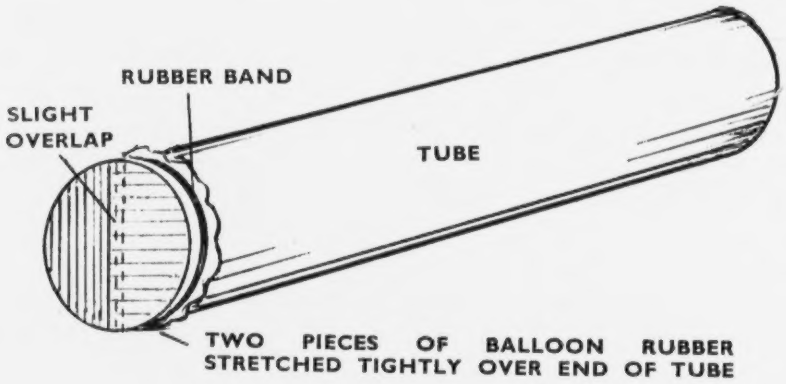
Place a straw in a bottle. Blow across the top of the straw.

Note.—Although vibration may not always be apparent, it will be seen that some degree of movement is necessary before sound is produced.

The Human Voice

Other activities might involve investigation of sounds produced by the human voice. Two suitable activities are suggested below.

- (*a*) Remove the ends from a jam tin. Cover one end with balloon rubber. Attach a piece of mirror glass to the centre of the rubber. Place the tin so that the mirror reflects light onto a wall. Shout at various pitches into the open end of the tin.
- (*b*) The " voice box ". To make a model " voice box " take a glass, plastic, metal, or cardboard tube about one inch in diameter. Stretch two pieces of balloon rubber tightly over one end and secure with a rubber band as illustrated below. The two pieces of rubber should overlap slightly. Draw or blow air through the tube from the other end.


RUBBER BAND
SLIGHT OVERLAP
TUBE
TWO PIECES OF BALLOON RUBBER STRETCHED TIGHTLY OVER END OF TUBE

MOVING

Note for Teachers

Energy is a fairly difficult notion, and the manner in which the term is used in this unit is not the same as that in which scientists use it. Here we are concerned with developing an idea which, in the case of students who study science in later years, will be the foundation of the scientific concept. In science, strictly speaking, energy refers to a certain, *measurable quantity* which is conserved in all changes involving material things. For example, in the case of a swinging pendulum, the potential energy of the bob (the weight of the pendulum) at its highest point is the same as its kinetic energy (the energy of motion) at its lowest point, if air resistance is non-existent. This can be expressed as an equation of two expressions, both of which can be calculated.

The idea of energy as expressed in this unit, and in its everyday use, while not inconsistent with the scientific term, is not the same, since we are not concerned here with measured quantities.

This unit describes some activities which should further develop the children's understanding of energy. The main theme is " Moving things can make things happen ".

At this level children might be satisfied to join in the planning of activities, to carry out the suggested activities, to observe what happens, to take part in discussions, and to attempt to record their thoughts and experiences.

The activities have been listed according to the materials used :

Balls and Marbles
Other Solids
Water
Air
Rubber Bands
Batteries
Clockwork Motors.

The order in which these are treated is not important.

Moving Balls—How a Teacher Introduced the Topic to a Fourth Grade

During a discussion period some boys described a game of skittles they had played the previous evening. The teacher suggested that it might be interesting to investigate the different ways in which different balls performed in a game such as skittles. In a games period which followed, children rolled, bowled, threw, bounced, and hit a variety of balls. They bowled tennis-balls at basket-balls, and basket-balls at tennis-balls, they experimented freely (and at this stage in a rather haphazard fashion) with marbles, ball-bearings, golf balls, table-tennis balls, cotton-reels, soft balls, and many others.

After the games period, the children were allowed to write freely about their experiences. Writing was done quickly on loose sheets of paper, which were collected and read by the teacher. Mistakes in spelling and expression were not taken into account at this stage, since the teacher regarded this work as a chance for the children to crystallize their ideas, and for the teacher to gain an insight into the level of the children's thinking.

On reading the children's descriptions of their activities, the teacher noted that very few had attempted to *plan* their activities. This, she decided, could be dealt with in the morning discussion period on the following day. Consequently, the need for planning experiments was discussed, and the teacher used the reports that had been handed in by two of the children to illustrate the point. Both examples used were written by children who had attempted to organize their activities, one more successfully than the other. This is what they had written :

First child

" I bounced some balls and this is what I found out.
Basket-balls bounce five times.
Tennis-balls bounce seven times.
A flat basket-ball bounces three times."

Second child

" The whole grade went out into the playground to find out if balls could have energy. I used my energy to bounce a ball. I think that it must have kept some of my energy because it didn't just bounce once. It kept on bouncing by itself for a few bounces. The more energy you put into the throw the more the ball will bounce.

1. Basket-ball :	great deal of my energy ..	9 bounces
	not much of my energy ..	5 bounces
2. Soft ball :	great deal of my energy ..	7 bounces
	not much of my energy ..	3 bounces
3. Cricket-ball :	great deal of my energy ..	4 bounces
	not much of my energy ..	2 bounces.

If you give a ball enough energy for a bounce it will still have energy for another few bounces."

The two children concerned read their reports to the grade. The following points came out of the ensuing discussion :

1. The first child had not thought of varying the energy he put into bouncing the balls. He could improve his report with the help of the second child.
2. The second child had arranged her results in order from the bounciest to the least bouncy. This made her report easier to read and understand.
3. If the children worked in groups to plan and perform experiments, they could help each other and would probably obtain more accurate results.

At the earliest opportunity, the teacher took the children into the playground where they formed into groups and attempted further experiments. Some children had already planned and started their experiments during lunch recess. Groups varied in size from two to ten children. Naturally the standards varied greatly, but the teacher reported a general improvement in the way most children performed, and in particular in the manner in which they attempted to set out their reports.

One or two children had attempted to draw simple graphs to record their findings. As the teacher had planned to introduce graphs in mathematics during the following week, she was able to use the children's science reports as an introduction which gave the mathematics period more interest and meaning.

When the teacher read through the children's reports she found several common errors in spelling and punctuation. These were made the subject of subsequent English lessons.

These activities occupied the children for some weeks.

Note.—The results from some of the experiments would probably be rather vague since there is no way of accurately measuring the strength of each child's throw. However, the children did realize that the amount of energy *they* used did affect the results. They also gained experience in working together to plan and carry out experiments, to describe events, to arrange data, and to draw simple graphs. They should have developed a fuller understanding of energy, and have come to realize that the energy of moving things can "make things happen".

It is hoped that from this stage children will experiment with materials other than balls. It must be stressed, however, that the order in which the different materials are used is not important. Indeed, it is possible that many different materials might be used at the one time. If the opportunity presents itself, individual children or groups may follow the lines of investigation that interest them most.

The following notes give a brief description of some further activities that may be developed. The brevity of these suggestions does not suggest that the activities are any less important than those described under the heading Moving Balls. On the contrary, what follows may well provide more interest and opportunity for activity than the first section, and may offer a chance to link science with craft and hobbies.

Other Moving Solids

Sand may be allowed to trickle through the hole in the bottom of a can. The force of the falling sand can be used to drive a wheel. Children might be interested in making a meccano model that could be driven by a stream of falling sand.

Moving Water

A jet of water from a hose can be used to clean leaves from a path, move balls (providing a link with Moving Balls), drive a water-wheel, and drive a meccano model. Water-wheels and models could also be driven by a stream of water running from a hole in the bottom of a can (as with sand).

Moving Air

This might involve experiences with jets of air from pumps, fly-sprays, or garden sprays, with hand fans and electric fans, and with wind. Wind moves yachts and turns windmills which in turn operate machines. Children might like to make their own model windmills which could be used to operate meccano models.

Rubber Bands

Use stretched or twisted rubber bands to move objects. Toy cars, boats, and planes can be driven by rubber bands.

Batteries

Examining, handling, and discussing batteries and electric motors. Using electric (battery-driven) motors to move things. (Refer also to the unit Batteries, Bulbs, and Wires). This could lead to the use of magnets to move objects.

Clock-work Motors

Examining, handling, and discussing clock-work motors. Using clock-work motors to move things. Discussion of the motion of a watch or a clock could take place.

Extracts from a Teacher's Diary

Background : Grade IV children—little or no experience with science. Only previous work was on discrimination between various leaves and kinds of wood. Class of forty, of average ability. About one-quarter immigrants.

" I started the topic by telling the children that they were going to play a game of marbles. Each child had two marbles and all had experience in shooting one marble and moving the other.

" The discussion that followed centred on what happened when moving marbles hit other marbles. It was suggested that the amount of energy put into firing the marble affected the result. Some children attempted to explain what was meant by energy. I thought it wiser not to attempt to obtain a definition of energy, so we went on to talk about other moving things which could make things happen. The children suggested air, water, and motors.

" We finished by commencing a science experience book on Moving Things."

" The children had brought along battery-operated toys, kites, rubber bands, balloons, and a variety of small objects. The class was divided into groups of about six. Children were free to find out how some things helped other things to move.

" The children discovered that *moving* things have energy to move other things—this was about as far as their thinking went at this stage. The children wrote up what they had discovered."

" We were talking about moving things and energy. Some of the questions we tried to solve were : ' How far do some things cause other things to move ? ' ' How can we measure this ? ' The children set to work to discover the answers for themselves. Group work was much better—the children seemed to have developed more purpose in their activities. Practice, I suppose. The results were eventually recorded in the experience books."

" The topic for art was ' Myself Playing Marbles '. I think ' Movement ' would be another good art topic."

" We were having a mathematics lesson on graphs showing the height of the children. Some children suggested that graphs could be used in science to show how far objects moved. I suggested that they should try this at the next opportunity."

" . . . commenced with all children outside. Attempts were made to fly a kite (mostly unsuccessful as I was not aware you needed wind to fly kites !). The children knew more about this than I did. They thought that moving air made the kite move. More observations in experience books."

" Level of interest has been very high so far—considered successful."

What the Children Wrote—Some Extracts from the Experience Books

" I pushed the first marble and the second marble got pushed by the first marble. We have energy to push the marble. The first marble has energy when it is moving because it pushes the second marble."

" Energy is what I call muscles. Energy is when you blow out air and when you hold onto kites and other things. When you shoot a marble the pressure of your finger lets go and the marble fires to hit the other one. The first marble has been fired the second one gets the first one's push and it starts to move."

" Some things move by force of other things.

These things move other things : water, electricity, humans, animals, wind.

Water pushes pebbles and shells.

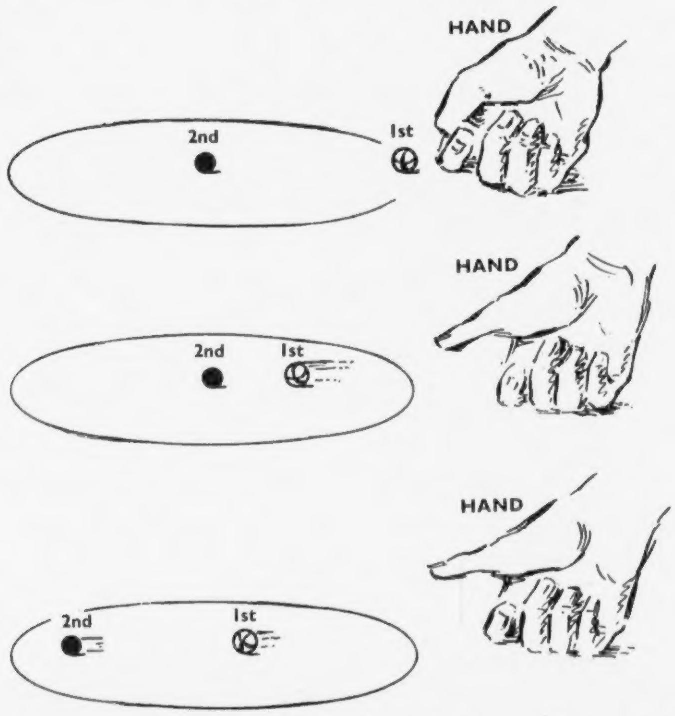
Electricity makes polishers move.

Humans push or pull to make things move.

Animals push or pull to move things.

Wind blows and moves trees.

When you push a marble against another marble they both move. The first marble has the energy to move the second marble."

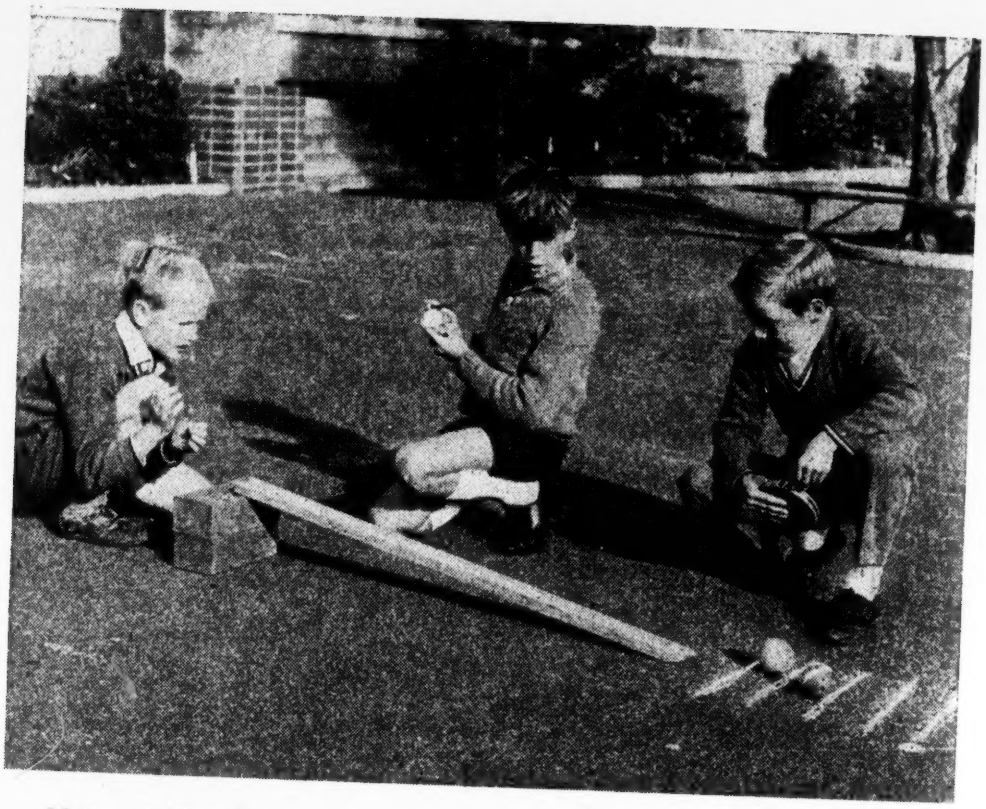


" Heavy things can push light things better. You can find out by getting something long (like a big ruler) and putting something light (like a marble) at the bottom of the long thing and something heavy at the top (like a tom bowler).

Then push the heavy thing down. Then you can get a ruler and measure how long it pushed the other thing which is the light thing. Then try it the other way and measure ; you can see the difference. That proves that heavy things can push light things easier."

" If you blow hard at a soft ball or anything light it will move because you gave energy to it."

" If you put a ball-bearing on a slope then let it go it will roll fast and each inch it goes it gathers more speed. Then when it hits the thing at the other end it will hit it off."



Note.—Mistakes in grammar and usage were discussed with the children. Science therefore provided an opportunity to introduce some work in English.

For further development along the lines of this unit, refer to Making Objects Move in *Branching Out*.

MAKING WORK EASIER

This unit is designed to give children experience in overcoming problems involved in moving heavy objects. The activities begin with attempts to push, pull, and lift objects. Further activities explore means by which the work involved in moving heavy objects can be made easier. This involves using runners, rollers, wheels, ball-bearings, levers, and pulleys ; oiling moving parts ; comparing rough and smooth surfaces ; constructing simple sledges, trolleys, and pulleys from available materials or from meccano sets or junior engineer sets. Some methods are suggested for measuring differences in the force needed to move objects.

Children might be expected to join in the planning and performing of experiments and the construction and manipulation of simple equipment, to observe what happens, to take part in discussions, and to attempt to record their thoughts and experiences.

Possible Starting-points and Related Lines of Investigation

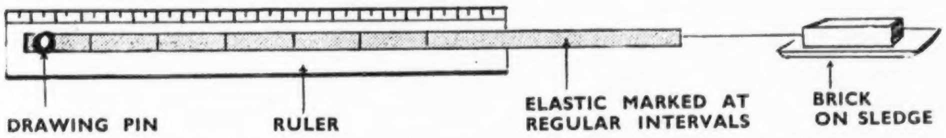
This topic may arise from, or lead on to, activities suggested in the units Moving, Magnets, or Soaps, Fats, and Oils ; from stories of inventors such as Stephenson and Watt, or scientists like Archimedes ; from social studies themes such as work, transport, building, the pyramids, the shadoof, Roman catapults ; and work involving model cranes, oiling the wheels of a bicycle or a billy-cart, and the use of graphs in mathematics.

Heavy Objects in the Classroom and the Playground

The children may be encouraged to attempt to push, pull, and lift various objects found in the classroom and the playground. It will be clear that in many cases the work involved is great, and that some objects cannot be moved just by pushing, pulling, or lifting. How can this work be made easier ? If the equipment mentioned above is made available, children will be able to experiment with different ways of making the work easier. The following activities might develop :

Runners

Simple sledges may be made, for example, by nailing strips of wood to the bottom of a banana case. A more efficient model could be made by using pieces of curved wood, such as sections from a barrel, as runners. Smaller models of sledges could be made to carry a standard weight, such as a house brick, and tests devised to test the efficiency of the runners. For example, a simple measuring instrument can be made from a piece of elastic, marked at regular intervals, and attached to a ruler by a drawing-pin. The other end of the elastic can be tied to the sledge. When the sledge is pulled the elastic will stretch, and the distance between the marks of the elastic will widen. The amount of stretch can then be read against the ruler.



Other useful measuring instruments can also be used ; for example, a spring balance attached by string to the sledge ; a flexible stick or a fishing-rod (rather inaccurate but worth trying) ; a hack-saw blade scale (see the unit Hardness, Brittleness, and Elasticity in *Branching Out*); spring-type kitchen scales used to *push* the sledge. These measuring instruments may also be used in the activities that follow. Further experiments might involve waxing the runners, using steel runners, and varying the surfaces over which the sledge is dragged.

Children will be able to record results in the form of tables and graphs, thus providing opportunity for integration with applied number.

Rollers

Rollers, for example, lengths of dowelling or pencils, may be used to make the work involved in moving heavy objects easier. The activities involved would be similar to those used to measure the efficiency of runners.

Wheels

Activities with wheels may follow along similar lines to those of the activities mentioned above. Perhaps the wheels could be made by cutting pencils and inserting wire axles through the holes from which the lead has been removed.

This may lead to examination of wheeled vehicles such as billy-carts, bicycles, and scooters. Children might be interested in making their own billy-carts. This would involve deciding upon the most suitable kind of wheels, and would also provide an opportunity to consider why oil or grease is used between the wheel and the axle. Appropriate safety rules should be discussed at this time.

Ball-bearings

The use of ball-bearings might arise in the construction of a billy-cart. Even if this does not happen, some experiments with ball-bearings can still be carried out. If the lid of a jar or a tobacco tin is inverted over several marbles, and a brick is placed on the lid, a type of ball-bearing vehicle will have been made and may be used in experiments similar to those described under the heading Runners.

Levers

Any work with levers should be of a simple nature without any reference to technical terms. Lengths of wood may be used to raise heavy objects. Common tools, which may be regarded as levers, may be handled by the children ; for example, a tyre lever, a hammer, wire-cutters, scissors, nut crackers, a can-opener, pliers, a pick, and a crow-bar.

Pulleys

Work with pulleys would also need to be of a fairly simple nature. As in previous activities, simple instruments may be used to measure the amount of force needed to raise a certain object (perhaps a house brick would still be most suitable as a standard weight).

Pulleys for blinds and curtains are available from most hardware stores. A cotton-reel will also make a suitable pulley.

Construction Kits

Further activities may be carried out with meccano sets or junior engineer sets.

Wheels and Cogs

Cog-wheels can usually be obtained from garages or from old clocks or clock-work toys. Children can explore the way in which cogs make work easier. Probably the best example is found on bicycles, particularly bicycles fitted with gears. Corrugated cardboard can also be used to demonstrate how cogs work.

Making Butter

This subject might arise from social studies, or be included in other units which investigate foodstuffs. *Pure* cream (not reduced or thickened with gelatine) can be made into butter by placing it in a basin, with a pinch of salt to improve the taste, and beating with a fork or a wooden spoon. This will involve a lot of hard work, which gives rise to the problem of finding an easier method of making butter. An egg-beater could be tried, then perhaps an electric mixer. An easier method still would be to use a butter churn which may be obtainable, particularly in some country areas.

Children might try other methods such as shaking cream in a cocktail shaker or other watertight container. Some thought might be given to means by which the hard work can be taken out of the shaking.

PART III

LIFE

PART III : LIFE

For a full understanding of the material that follows it is essential to refer to the introductory remarks on life in the *Course of Study for Primary Schools, Science.*

COLLECTING AND CARING

Refer to Appendix I, Collecting and Caring, in Curriculum Guide A—*Beginning Science*.

This unit is important at all levels in the primary school.

GROUPINGS AND STRUCTURES

Work in this unit should provide teachers with the opportunity to—

- continue the development of multi-sensory discrimination abilities ;
- provide opportunities for children to bring order into the information they obtain, by making groupings according to logical systems that they themselves develop on the basis of the facts observed ;
- provide opportunities for children to draw conclusions about the great variety of living material and the fundamental similarities shared by all living things.

In this unit the emphasis in the investigations is on structural similarities and differences. Information on these matters should be derived from direct observation of the living material collected by the children, including material similar to that suggested in the previous unit, Collecting and Caring.

Suggested Method

It is not sufficient to look at the material being studied and then to discuss what has been seen. Observations made in this way tend to be superficial and fleeting. Some observations need to be made with the aid of a magnifying glass, or even a microscope, but the most useful aids are a pencil and a piece of paper. If children are asked to write down all that they can find out about the materials being observed, the result will not only be a worth-while exercise in English, but it will also be an encouragement for children to observe more closely, and so to become aware of the fine distinctions between the materials being studied. It is unlikely that children in Grade III will draw many conclusions or be able to make generalizations on the basis of the comparisons they make, but the ability to do so is something towards which they should be heading, and perhaps they may begin to achieve this in Grade IV. At the very least, however, they should be building a store of experience about which they should be able to generalize at a later stage. For example, a study of items could develop in the following way.

The children's interest may be aroused by observation and discussion of bamboo. Some children like to make mock pipes from gum nuts and lengths of bamboo ; some find bamboo good for making spears and bows ; others find bamboo ideal for making illegal pea-shooters. Bamboo is therefore a highly desirable material, and most children consider it worthy of close study. Bamboo might be the basis for a rich and varied collection. Other material collected might include stems and twigs of—

pumpkin
geranium
eucalypts
dock
clematis
cactus
nettle
daffodil
arum lily
sweet pea
sugar-cane
grasses
rhubarb
poppy
rose
rushes
sunflower
Moreton Bay fig
acacia
celery
pine.

This list by no means exhausts the possibilities, but it does include twigs and stems that are hollow, prickly, juicy, fibrous, rough, thorny, sappy, and flexible.

A group of children, not necessarily the whole class, might then use this material to make an interest book with a title such as " Our Museum Book of Stems and Twigs ". It is not inconceivable that some children will be able to write a page or more about each specimen. The children should be encouraged to offer suggestions as to why the similarities and the differences they detect are present. These suggestions could provide the basis for discussion and further investigation.

Other groups of children might study roots, leaves, fruits, flowers, buds, seeds, and timbers.

Insect, Animal, and Man Structures

Little needs to be said about the details of these studies, which could cover the whole range of animal life, including birds, reptiles, and snails, as suggested in the unit Collecting and Caring.

Children might also study some of the following :

feathers
skulls
mouths and jaws
coverings (hair, fur, skin)
legs
teeth
bones
eyes and feelers.

Human beings (the children themselves) should be studied. Comparisons of the skeletons of human beings, chickens, and cats, and the exo-skeletons of crabs, spiders, and insects can lead to a deeper appreciation of human physiology and associated topics in health and safety.

Groupings

Children should be encouraged to make groupings on the basis of their observations. Their systems of classification will probably differ greatly from accepted adult ideas on the subject, but this is of no importance, provided the groupings made have some logical basis, in which case the work children do in this area during the year may be useful as a means of indicating development of their ability to order a widening range of experience in a logical way.

The following grouping was made by a Grade IV child early in the year :

Crawler	*Flying*	*Butterflies*	*Biters*
lizards caterpillar	flies bees wasp moth butterfly	case moth black swallowtail monarch	dog lion man
Hoppers	*Insects*	*Water*	*Singing*
grasshopper praying-mantis	ant locust lady-bird	crabs yabbies fish	cricket

In itself, this grouping gives a valuable insight into the child's thinking ; it would be even more valuable if it could be compared with groupings made later in the year.

The Heart

The following suggestions show one way in which a part of this unit can be extended.

Possible Starting-points

Children's pets brought to school for a short-term study in connexion with work on mammals (perhaps replacing the unit on mammals where work may be difficult or undesirable).

Pets kept at school—guinea-pigs, white mice, birds, lizards.

Newspaper reports of " hole-in-the-heart " operations.

Timing experiments in which the heart-beat is used as a measuring device.

Negotiations with the local butcher for material to examine. This might include bones and eyes. In the context of a general interest being developed, an interest in one item, such as the heart, may be aroused.

Running around the playground on a frosty morning to get warm before commencing lessons.

These suggestions represent only a few of the possibilities. The reason for listing them is simply to emphasize that an incidental introduction, even though it may be at least partly contrived, is desirable.

Preliminary Activities

Question children about the things that interest them when they think about the heart. List these interests, and it may happen that they will stimulate the children to undertake some satisfying investigations. If this happens, what follows in the next section may be ignored. The more children can be encouraged to raise problems for themselves, the better it will be. On the other hand, children's suggestions may not be sufficient, and the questions given below could be used to develop their awareness of the possibilities for further experimentation.

In any case, if children do ask questions at this stage, the teacher should ask them how they might go about finding answers to their problems. If their suggestions can be followed up, the children who provided the problems and those who suggested the means of solving them should form groups to carry out their activities and to report their findings to the class. The teacher may be aware of difficulties that the children do not foresee. He should use his discretion in deciding whether to reject or alter the children's plans. *All experiments in science do not succeed, and children need to taste failure as well as success.*

Further Activities

Some problems which may be posed if children do not provide enough are given below.

How could we magnify a heart-beat? (This would involve the making of stethoscopes from cardboard or paper tubes, or from plastic funnels and lengths of thin rubber or plastic tubing, depending on what material children are able to gather. A tape recorder could also be used.)

How rapidly does a heart beat?

How could we time heart-beats?

Is the heart-beat rate of a boy the same as that of a girl or of an adult?

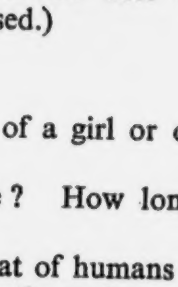
Does the heart beat more rapidly after exercise? How long does it take to return to normal?

Does the heart-beat rate of animals differ from that of humans? (A number of problems indicated here lend themselves to simple work with bar graphs, and such links with mathematics should be encouraged.)

What does a heart look like? (Readily available hearts of a sheep or a rabbit, for instance, would provide material for dissection. The relation of the chambers to one another could be discussed and appropriate library books referred to.)

How do pumps and valves work? (A question of this nature would follow naturally, and children might like to construct some models which show how valves work. Preliminary examination of a bicycle pump and a tyre valve would be useful. The simple kerosene pumps sold by some hardware stores could also be examined.)

A way of showing the pulse is by using a small pointer made by pushing the point of a drawing pin into the end of a match or a narrow strip of card bent at right angles. The outstretched hand, relaxed limply and slightly turned so as to bring the pulse upwards, is rested on the desk. The pulse is found by using the fingers of the other hand. The drawing pin is stood on the pulse. The pointer will then jump with each pulse and the pulses may be counted easily. This will work more readily with some people than with others. The movement of the pointer is only slight, but more movement will be evident after vigorous exercise.

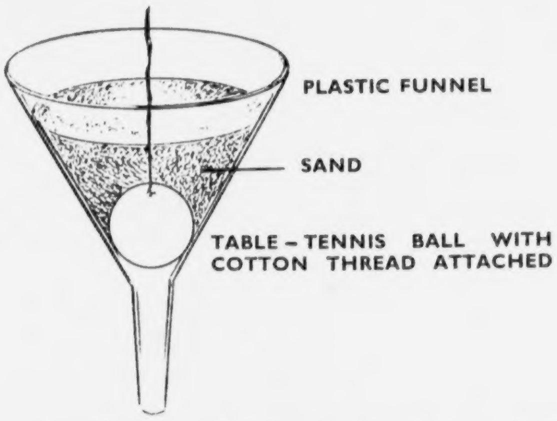


In one Grade IV, children bought hearts from the butcher's shop and brought these to the school for dissection (large bullocks' hearts were preferred). Working in small groups of two or three, the children began by examining the hearts. Although some children were apprehensive at first, they soon cut the hearts open, trying to trace the path of the blood through the heart. Some children had heard of heart valves, but the teacher did not make mention of these at this stage, leaving the children to speculate on what they discovered. Most groups kept notes of their observations, and these were used as a basis for later discussion. Some library research followed. Over the following weeks many children reported that they had dissected hearts at home, sometimes with the whole family joining in.

The cost of supplying so many hearts was offset by the returns from selling them to children as pet food.

A tape recorder was used to amplify heart-beats. The controls were set to " amplify " (an alternative method would have been to record the heart-beats and to play them back), and the microphone placed over a child's heart. The child then sprinted around the playground and his heart-beat was again amplified. The change in the rate of the beat was evident.

Children could be encouraged to make models as part of their creative activities. It would help to have on hand some table-tennis balls, marbles (for a ball valve), a funnel or two, some plastic tubing or metal pipe, and some thin leather (the tongue of an old shoe). The leather could be used to make a valve that works like a flap, letting sand or water past, but cutting off any backward flow. A ball valve may provide more difficulties, but the snorkel breathing tube that many youngsters use while swimming is an example. In the snorkel, a table-tennis ball prevents water from flowing back up the tube. A typical model that could be constructed to illustrate the principle of the ball valve is shown below.

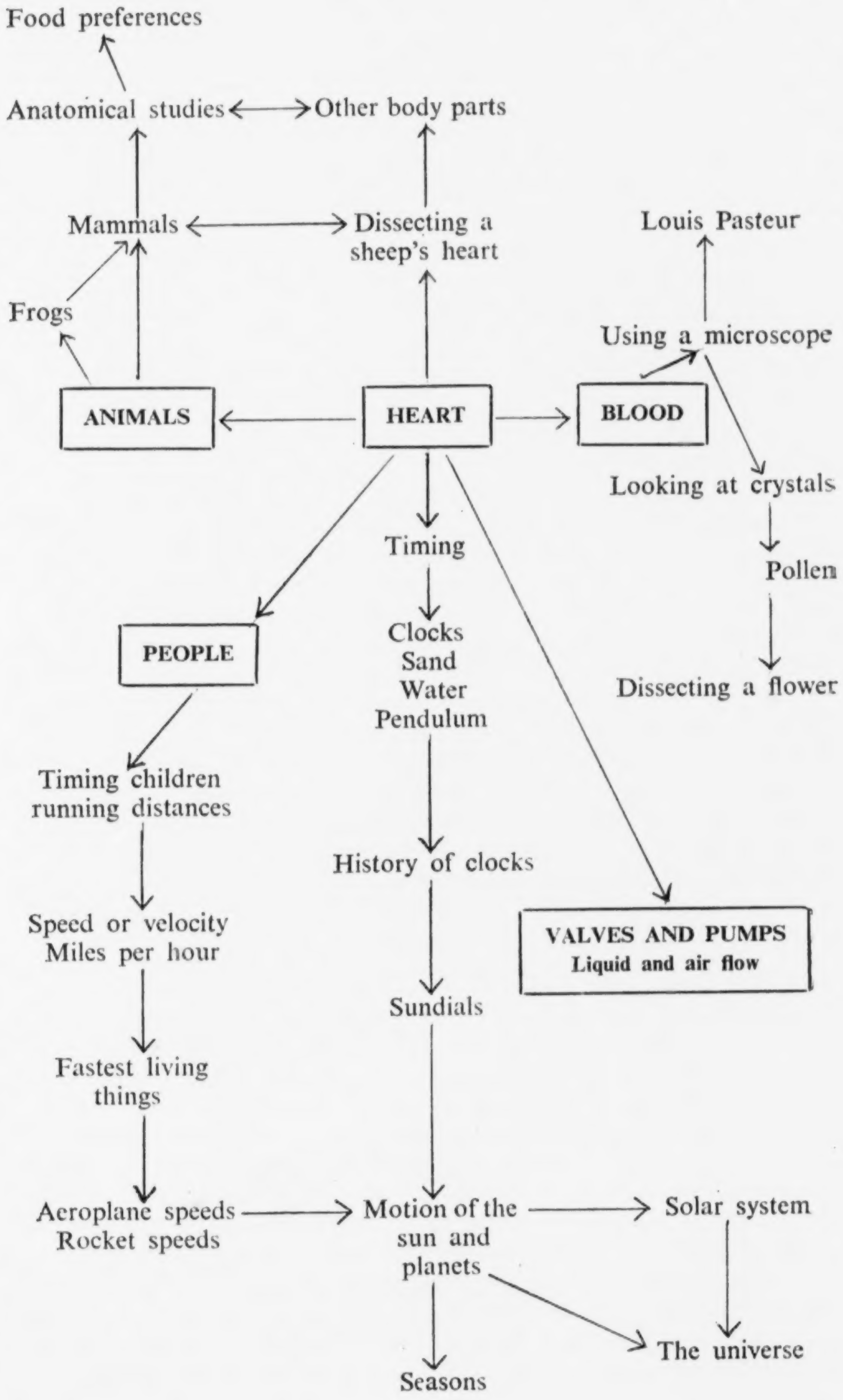


This is a sand hopper. The sand flows down when the valve—the table-tennis ball—is raised by the thread. A hinged leather flap across an opening would be a closer approximation to a heart valve, but the whole subject in its wider form and application may possibly interest some children.

Possible Further Developments

It may happen that other fields for investigation will open up as the study develops. If these topics appear to be fruitful, that is, if children are likely to ask more questions, suggest further experiments, and advance ideas to be tested, it may be profitable to abandon the original interest, at least temporarily, and to follow the new leads. In other words, branching studies should be encouraged if they provide situations in which the attitudes, the ideas, and the skills of science are developed. A sample flow chart appears on page 87. Only a few of these topics may arise and there are many others which have not been included. The flow chart is in topic form, but it is not the subject-matter of the topic that is of prime importance, but the way in which the problem is attacked.

A TYPICAL FLOW CHART


Food preferences
Anatomical studies
Other body parts
Mammals
Dissecting a sheep's heart
Louis Pasteur
Frogs
Using a microscope
ANIMALS
HEART
BLOOD
Looking at crystals
Timing
Pollen
PEOPLE
Clocks
Sand
Water
Pendulum
Dissecting a flower
Timing children running distances
History of clocks
Speed or velocity
Miles per hour
VALVES AND PUMPS
Liquid and air flow
Sundials
Fastest living things
Aeroplane speeds
Rocket speeds
Motion of the sun and planets
Solar system
Seasons
The universe

BEHAVIOURS OR WHAT LIVING THINGS DO

This unit is designed to provide opportunities for children to develop their abilities to—

- make observations and comparisons and to write carefully worded descriptions ;
- design and carry out simple experiments.

At the same time it is expected that children will gain some appreciation of differences and similarities in plants and animals in relation to movement, growth, foods and feeding, and protective mechanisms. The following questions are considered :

What Does It Do ?
How Fast Does It Grow ?
How Does It Feed ?
What Is Its Food ?
How Does It Protect Itself ?

What Does It Do ?

In one Grade III, the children made a book of the descriptions they had written during and after observation of animals kept in the classroom. In the classroom there are ants, lizards, fish, white mice, and budgerigars. At suitable times during the day, over a number of weeks, individual children took a pad and a pencil and sat watching the particular creature they wished to study, and noted its actions in detail, sometimes when the creature was being fed but usually when it was engaged in its normal activities. Later each child reported to the class what he had seen, and discussion followed. Even the smallest movement of an ant's feelers came under scrutiny and led to discussion.

Work with plants could be handled in a similar fashion, but with some differences due to the slower rate of change. For example, if seeds are being germinated, or seedlings grown, children could make a careful search for small changes, comparing perhaps six plants. Once again this could be a task for one child working during some free time when his other tasks have been completed.

How Fast Does It Grow ?

Growth may be measured by noting changes in weight or size (length, number of leaves, girth, number of shoots). In one school, work proceeded over several months and was begun with climbing beans planted in the school garden. Ground preparation, plot marking, and planting were all done by the children, who followed the instructions on the seed packets. Several types of climbing beans were compared. Climbing frames were constructed by the children from scrap timber and twine after they had decided on a suitable design. Extra stringing was found to be necessary as the plants reached maturity.

A class book was made in which observations were noted—both written descriptions and tables or graphs. Comparisons were made of the time taken for the plants to break through the soil surface, the climbing rate, the appearance of tendrils and the number of them, the appearance of buds, flowers, and pods, the length of the pods, and the number of seeds in various pods. Interest remained high after the beans had been planted, and, as a result, work was undertaken with a number of seedlings of other types.

Where it is impossible to grow plants out of doors, similar work can be undertaken in the classroom, but care should be taken to see that children work with a variety of plants so that useful comparisons can be made.

Work undertaken with animals might involve weighing or measuring. Suitable animals might be chickens or kittens. Even the children themselves are good subjects, not only the children in the class, but also younger and older children, selected at random and measured over a period of a term, or longer if possible.

How Does It Feed and What Does It Eat ?

Investigations might be undertaken with birds in the school-ground to discover their feeding habits. Observations should be made on wet days and on dry days. Perhaps a bird table could be set up near the classroom window for more intensive observation.

Snails, slugs, ants, and caterpillars may be observed feeding in their natural surroundings. Children might then like to design some sort of controlled experiment in the classroom, using whatever animals are available. (Consult the unit Collecting and Caring.) In this way it might be possible to come to some conclusions as to food preferences and the quantity of food consumed each day. Observations should also be made of the actual feeding process.

Comparisons with human beings are important, and these may lead to the consideration of the following matters :

Diet of peoples throughout the world.

Diet of children in the class. Daily menu charts could be prepared showing foods actually consumed ; it is likely that these will show considerable variation, due to individual and family food-preferences.

Estimation of the weight and the intake of various foods, for example, school lunches. Some children might like to calculate this on a daily or a weekly basis, or even on a yearly basis if their mathematical abilities are sufficiently advanced. Kitchen scales are quite adequate for most of this work. Results could be presented in the form of graphs or tables.

A variety of nutrition studies could be undertaken with plants. Various brands of plant food are available and could be used. Seeds such as beans could be planted in washed gravel or sand containing measured quantities of plant food, and results compared. Other substances such as superphosphate, lime, and cow or fowl manure would also be suitable for experiments, the design of which should be decided upon largely by the children themselves.

The possibilities for follow-up work in country schools are obvious, but even in the city a visit to a plant nursery at this stage would be very profitable.

Protection

It is not unusual to hear people say that roses have been given thorns to protect them. Roses have not been *given* anything. It is also said that many Australian plants have tough leaves to prevent water loss and that poppies have hairy stems to prevent ants from crawling up them. In this case, smooth-stemmed plants may appear to be at a disadvantage, and it may be difficult for some children to understand why the swamp-gum has leaves similar to those of a gum-tree growing in more arid regions.

Many plants do have protective adaptations, but these have not been provided by a kind and thoughtful Mother Nature. Rather, they have appeared as the result of a long series of slight mutations—small, inheritable changes gained by chance—that have given the plants certain survival advantages in the habitats in which they have become established. These advantages may not always be connected directly to the situations in which the plants are now growing. The leaves of many Australian plants are tough, but this may be due in part to nutritional factors. It is believed that the shortage of certain elements in Australian soils plays a part in producing the typical woody, tough plant that is found in many parts of the land, moist as well as dry. Similarly, other adaptations may be the product of a diversity of hidden factors. This note of caution needs to be sounded before embarking on a study of protective adaptations or " behaviours " in a wide use of the term.

Broadly speaking, protective mechanisms in both plants and animals could be considered as being of two types—one of structure and one of behaviour—but such a division has been suggested only to provide children with a starting-point for their own investigations, which would almost certainly involve the use of simple reference books as well as observational studies.

Finally, it must be said that any plant in its natural habitat has, through adaptation, developed protective devices. A short-lived plant that scatters many seeds is a case in point.

For observational work some useful plants would be grasses such as couch, marram, kikuyu, and buffalo ; bracken fern ; thorny plants such as blackberry, box-thorn, and the rose ; onion grass ; nettle ; cotoneaster and other plants that thrive on hard cutting back ; hakea and some of the eucalypts that withstand fire (these are included mainly for country children) ; the nasturtium and other plants with bitter-tasting leaves ; and cacti, both with and without spines.

A number of these plants could be compared with other plants that do not exhibit the same protective mechanisms. Some possible comparisons are :

Nasturtium—lettuce. Offer the leaves of both plants to snails and note the results.

Cactus—hydrangea or pumpkin. Compare a pumpkin plant germinated in a pot of soil with a cactus in a pot. Withhold water from both plants and note results.

Cotoneaster—bean plant. Remove the upper part of each plant and observe them over a period.

Couch—rye or fine lawn grass.

Similar work is possible with animals. Initially, children should study animals that are readily available, and later extend their knowledge by using library books. Briefly, typical protective mechanisms among animals include camouflage, sting, bite, shock, rapid movement, no movement (guinea-pig), emission of repulsive gases and liquids (ant, skunk), a fearsome appearance (frilled lizard, dog baring teeth), and bright colouration (certain fish, caterpillars)—probably the bright colours act as signals of poison or of an offensive taste.

A topic such as this is likely to arise out of activities in collecting and caring. Once interest has been aroused, the children should be encouraged to suggest several protective mechanisms that might operate, and then to search for plants or animals that exhibit these structures or behaviours. In the course of the work it is likely that other mechanisms will become apparent. It should be emphasized that the protective devices mentioned above should not be taught as part of a cut-and-dried lesson. Rather, they have been suggested as starting-points for individual or group investigation as part of the manifold activities in collecting and caring that children undertake.

This work should also provide topics for children's writing and class or group interest books, which will incorporate discoveries from direct observation as well as information gained through reading.

LIFE STORIES

This unit provides a miscellany of activities on the following topics :

Life Stories—plants and animals ;
Reproduction ;
Strange plants and animals ;
Decay and preservation.

Although much of the work will be observational, a good deal of it will involve discussion, reading, and the making of individual or group interest books. The main purpose of the unit is to arouse and maintain *interest*, *curiosity*, and *discussion*.

Plants and Animals

Activities should involve investigation of the beginnings of living things and the changes that take place as they develop to maturity. Rather than study one plant or animal in isolation, children should study as many as is practicable, so that fruitful comparisons can be made.

Plants

Probably one of the best introductions to these studies is to start a vegetable garden, out of doors if possible. Interest in the particular topic is likely to be a natural outcome of the whole activity, which would involve children in—

- selecting suitable seeds such as radishes, which mature rapidly ;
- deciding the size of the plot, measuring it, and turning and manuring the soil ;
- planting the seeds in rows ;
- organizing a roster of children to water and weed the plot.

As a result of this work interest may be aroused in germination, and children should note how long it takes from the time of planting to the appearance of various parts of the plant. Germination studies of seeds of different kinds could be carried out, and comparisons made.

Later, children could make charts or large wall pictures showing differences in the size of the seeds, the seedlings, and the mature plants. If drawings are attempted, useful discussions might be held on how the size of mature plants (such as a climbing bean or an oak-tree) as compared with their seedlings might be shown in the drawing.

Other studies might include watching and timing the unfolding of a leaf or a flower bud, the growth of a fruit, and the eventual withering and fall of the leaves.

Animals

Work should develop naturally as part of Collecting and Caring activities. Some of the work done will be concerned with life-cycles. Most children have kept gum emperor caterpillars and watched them spin their cocoons. Some of the children may have watched the moth emerge from the cocoon many months later.

It would be unfortunate if the gum emperor was the only creature studied in this way, particularly as the life-cycle is a comparatively long one and interest tends to be spasmodic. For this reason it is worth keeping other caterpillars with shorter life-cycles. One of these is the painted apple moth. Some details that would be useful for a study of this moth are given below.

The Painted Apple Moth

The larva can be recognized by the position of tufts of hair on its body. At its greatest length it is about 1¾ inches long, and rather slender. The head is dull reddish-brown, and a slender tuft of hair projects from each shoulder to beyond the head, the top of each of these long hairs forming a swollen lance-shaped point. Along the centre of the back from the centre of the first four abdominal segments there is a thick bunch of greyish-brown hairs, giving a toothbrush-like appearance.

As well as these distinctive tufts, the whole of the upper surface of the caterpillar is covered with long brownish hairs, with patches of shorter grey hairs along the side, a large projecting plume being formed on each side towards the tip of the abdomen.

Once the larvae have been recognized, a collection should be made and several kept in cages or other suitable containers in the room. The painted apple moth is an Australian native, and its host plant was originally the wattle, but it now feeds on apples, roses, geraniums, cherry-trees, and other introduced plants. A few fresh leaves of the plant from which the larvae were taken should be introduced each day (the larvae will survive a week-end without fresh food). After a few days cocoons will be spun, and this exciting event should be a good time for the children to begin recording their observations.

The actual cocoon is loose, light-brown, and very flimsy, and the pupa can be plainly seen through it. More than half of the number of pupae are fully twice the size of the others. This can be a subject for speculation as to the reason for it ; later observation will provide the answer.

After about two weeks the adults will emerge. (In the winter they will remain in the cocoon for several months.) One adult will be winged, about one inch across the wings, and the two pairs of wings will be marked with yellow, orange, and black patches. The other type of adult, from the larger pupae, will be short, rounded, without wings, and covered with brown down. This type may be seen to lay eggs ; it does little else in its lifetime. Observation will enable the children to answer the earlier question—the larger pupae were the females.

The children should be able to describe the adult insects, the eggs (which are dull-white and very numerous), and where the eggs are laid (probably on top of the cocoon), and to record the time taken for the eggs to hatch.

There should be an opening here for creative work, perhaps for modelling or drawing the insects (not for scientific accuracy, and naming of parts is definitely *not* required), which will encourage the children to make careful observations ; or perhaps if the colours of the male adult or the hairiness of the caterpillars interest the children, they could paint them.

Children may notice that the eggs are not cared for. They should observe and describe the caterpillars when they hatch out. When they emerge, the caterpillars are nearly black ; by the time they are a quarter of an inch long they are brownish in colour. They will undergo several moultings before reaching full size.

If possible, and if interest is maintained, observe (without making detailed observations and recordings) two or three life-cycles, so that children gain a clearer idea of the continuity of life.

Discussion should be encouraged about questions such as the following :

Would a caterpillar lay eggs?

We see insects at some times during the year and not at others. Where might they be when we don't see them around?

Why do you think there are so few caterpillars to be seen before the middle of summer?

Other creatures, such as frogs, could be studied in a similar fashion.

In many cases the whole life-cycle cannot be studied, but the birth of pups, kittens, white mice, or fish such as guppies would provide opportunities for further consideration of birth, parental care (if any), and stages of development.

At some stage, comparisons with human beings would be fruitful, and any information about baby brothers and sisters or family life in general would be valuable. At this point an activity which may have started off as science may become English or social studies as discussion becomes focused on family life and parental care, or on stories about parents or grandparents, when they were young. This blending of activities should be welcomed if it occurs.

Reproduction

Mammals produce their young alive ; chickens hatch from eggs, as do caterpillars, ants, and some young snakes. Some creatures are sexed, either male or female ; others are both male and female, and yet require fertilization from another of the same species.

In plants, reproduction may occur by cross-pollination or self-pollination and the production of seeds. Other plants reproduce by spores, while there are others that reproduce themselves from a broken branch or twig or root.

This brief survey by no means exhausts the possibilities, but it suggests that there are many investigations children can make in this area.

Plants

Work with a variety of materials is likely to prove most useful. Pieces of mouldy fruit, vegetables, and bread can provide source material with which to start a mould garden. Children will note that the moulds spread, but that there are no obvious " seeds ". There is no need to go into details about spores at this stage. It will be sufficient if children conclude, after studying other plants, that not all plants make new plants in the same way.

Work with potatoes often proves interesting to children, notwithstanding the fact that it needs to be continued over several months. Plant whole potatoes, sections with eyes, sections without eyes, and potato peelings. In addition to planting these in the school garden other pieces should be planted in glass containers so that any development can be readily observed.

Strawberries, couch-grass, gladioli, onions, alyssum (sweet Alice), radishes, nasturtiums, and geraniums are plants that could be grown either in window-boxes or in the garden. Children will note how a strawberry plant sends out runners. and they may compare this process of reproduction with the somewhat similar process by which couch spreads.

Comparisons between onions and gladioli will show that the gladiolus corm produces new corms, whereas the onion normally reproduces itself by seeding or by the production of small aerial bulbs.

Both alyssum (sweet Alice) and the nasturtium are easy to grow and produce many seeds, which germinate readily.

The geranium grows from a cutting, and roots can be seen forming if a stem is placed in water.

The plants listed above are by no means the only ones that could be used, and the greater the variety. the greater the interest is likely to be.

Animals

Even if animals cannot be kept in the classroom for an extended period, it should be possible to provide temporary accommodation for a few days, and in these circumstances some discussion may occur on reproduction and care of the young. In any case, children frequently tell the class when their pets have produced young ones, and this provides a natural opportunity for discussion.

Smaller creatures such as ants, frogs, lizards, pet birds, spiders, and caterpillars are commonly kept in the school and present many opportunities for investigation. However, work with mammals is likely to prove more exciting for the children.

If the animals are kept for some weeks, the children may be able to observe the reproductive cycle, including the birth of the young. The gestation period for rabbits is about 30 days, for guinea-pigs, 68 days, and for white mice, about 20 days.

Children may note that the babies do not hatch out of eggs (although they commonly say the mother rabbit has " laid " some babies), but that they are born alive. Similarly, they may note that the young are fed milk by the mother. Children may also note the variations in the sizes of litters and the differences between the baby and the adult animal. As a result of their observations they will probably be able to give information on how the babies are cared for, the protective instincts in the mother, and the role of the father.

Teachers may wish to tell children how the baby grows from a tiny egg in the mother. The role of the father can be explained if necessary by reference to the different anatomical structures children observe, and by saying that the father animal gives the mother animal a " sperm " or living particle that makes the egg grow. Deciding how much to tell the children can sometimes be difficult. If questions are asked by one or two children while the rest of the class are busy with something else, the teacher may prefer to direct the explanation at the interested children. Only the circumstances and the feeling for the teaching " moment " can guide the teacher. Most children are satisfied by an explanation of the mother's role. If the father's role is queried, the approach suggested above would appear to be natural and suited to a primary school situation.

Note :—The entire section above has been taken from *Beginning Science,* because what was written there would seem to apply equally well to the upper grades.

It must be emphasized that any work done should be a natural outcome of the collecting and caring activities of the children.

Strange Plants and Animals

Children at this age are often very interested in collecting information about the world. They like to pore over simple reference books, and their reading may stimulate interest in the study of the materials that are available to them. For example, reading about rubber-trees may lead to a search for plants that produce large quantities of milky sap ; reading about certain types of ants may lead to an interest in studying the ants that are available locally. Some of the topics that may be studied are listed below.

Strange Plants

moulds
fungi
parasites
seaweeds
cacti
giant trees
fire-resistant plants (wattle seeds)
fly-traps
plants that respond to touch (mimosa)
poisonous plants
orchids
useful plants (herbs, oil-producing plants)
stinging plants and trees
plants with gigantic leaves
latex-producing plants
jungle plants (strangling figs, vines).

Strange Animals

Australian animals
strange fish, anemones, hermit-crabs
weaver-birds
ants
fast-moving animals
direction-finding animals
migrating animals
clever animals (elephant, porpoise)
animals that live to a great age
animals that hibernate
poisonous animals
bats
eagles, vultures
prehistoric animals.

Decay and Preservation

Decay

It is an ironic fact of life that it depends on death. The lowest forms of life, such as bacteria, depend for their existence on a continuing supply of dead plant and animal life. As they feed upon it they make available a store of chemical compounds that the coming generations of plants and animals can use.

The death of some plant or animal, or the decay of some piece of once-living material such as an orange or a tomato, may often be regarded as the end of an investigation ; but it should also be recognized as marking the beginning of another. In one class, the death of a sparrow provided children with an opportunity for performing funeral rites, and the bird was interred with considerable ceremony. Later in the year, other creatures including a gold-fish and a wild mouse died and were buried. Subsequently, the skelton of a bird was brought along and children speculated as to the present state of the creatures they had buried earlier. The teacher played no part in the subsequent proceedings, but after recess the remains of the buried bird were displayed to the interest and the satisfaction of the class, if not of the teacher. However, at this point it was possible to channel the children's interests into a more appropriate activity, and observations of decay continued over a number of weeks.

Some Suggested Activities

Collect food materials of animal and vegetable origin, such as pieces of meat, milk, butter, cheese, bread, leaves (lettuce, silver beet, cabbage), mushroom, fruits (apricot, peach, orange, apple, grape, raisin), and vegetables. Leave these for a time, a fortnight perhaps, and then examine them. Encourage discussion on how the materials should be kept for observation. Small jars make useful containers, and disagreements such as whether lids should be screwed on, whether the jars should be kept in cool, warm, shady, or sunny places, and whether the materials should be moist or dry will need to be resolved.

If some foods are kept in uncovered containers in the open, flies, maggots, ants, and birds may be seen at work. The question may arise as to what would happen if the materials were buried (like the dead bird), and this could lead to further investigation.

Moulds may be seen growing on some materials but not on others, and speculation as to what causes the rotting should be encouraged. This may lead to the examination of a rotting piece of wood or of humus, or to attempts to identify rotting materials and possible causes of decay.

Another line of inquiry could then involve the study of the role of this decaying humus in the garden or the bush. Seeds could be planted in washed sand and in sand to which a few handfuls of humus have beed added.

Further discussion on moulds will be found in ***Branching Out.***

Preservation

A natural outcome of studies dealing with preservation, especially if some dried, long-lasting item such as a raisin is included, would be a consideration of the problems of preserving foods. Briefly, methods of preservation include—

drying (in the sun or elsewhere).
cooling,
canning,
freezing,
adding salt, vinegar, or sugar.

Children may attempt to preserve some foods, and a good recipe book would be invaluable as a source of ideas. However, some suggestions are given below.

Drying

Suggestions will be found in the unit Water in Foods.

Pickling

A group of children could obtain information about pickling meat from a local butcher.

Pickled Cauliflower. The following is an 18th-century recipe :—

> " Cut into flowerlets, and boyle them for 10 minutes, in a cloth with milk and water. Then drain.
>
> Heat white wine vinegar with cloves, mace, nutmeg, and white pepper. Let it cool, then cover the Colly Flowers with it. It will be fit for use in three days."

Salting

During the last war, home vegetable growers endeavoured to preserve their surplus beans by salting them. The following recipe is from Bulletin No. 43, *Preserving Fruits and Vegetables*, published by the Department of Agriculture.

Dry-salting French Beans

Select fresh young beans, and have a suitable earthenware or glass jar or crock. Put in a layer of salt, then a layer of prepared beans about 1 inch in depth, then another layer of salt (using about 1 lb. of salt to each 1 lb. of beans), and so on till all the beans are in. The top layer should be of salt.

Then put over the beans a plate or clean board and weight it with a cleanly-scrubbed brick or other suitable weight. An iron weight of any kind should never be used. Cover with a piece of clean muslin, and set in a cool place.

The salt will extract the water from the beans and form a brine, which usually covers them in from 24 to 36 hours ; but if a sufficient quantity be not formed to do this, a little strong brine should be added (½ lb. of salt to a quart of water). If sufficient water is drawn from the beans there is no need to add more.

The salt should be evenly distributed throughout when putting the beans down, so as to avoid, if possible, the necessity of adding more brine.

The top layer of beans should be kept under the surface so as to prevent moulding. The jar may be covered to stop evaporation, and as they are wanted for use they may be taken out, washed, and soaked in several changes of cold water. When they are being cooked, the first lot of water should be drained off as soon as it reaches boiling point, and the beans once more placed in fresh cold water.

Jam-making

The sugar acts as a preservative. If conditions are suitable, a small quantity of jam can be made in the classroom as part of a survey of methods of preservation.

Cooling

Children might compare apples, tomatoes, or bananas kept in a warm sunny spot with fruit kept in a cooler place. A variety of foods kept under refrigeration could also be compared with foods kept in a warm place.

This work blends naturally with social studies and could lead children to investigate the means by which people in the past, and primitive people today, preserve their food. These methods could be compared with modern methods of pasteurization, canning, and freezing. Excursions and stories about Redi, Spallanzani, and Pasteur, for example, could serve to heighten interest in the activities.

A Final Note

Children should be warned against the dangers of eating contaminated food. Even the normal methods of home bottling are not perfectly safe for some fruits and vegetables because they are either non-acidic or weak in acid content. The Department of Agriculture, for example, advises *against* the home bottling of peas, beans, beetroot, carrots, peppers, vegetable-soup mix, asparagus, mushrooms, olives (unless preserved by a salting or pickling method), rock melon, cantaloup, or pawpaw. Beetroot preserved in a solution of vinegar, and tomatoes and rhubarb are quite safe to bottle.

" The only safe methods to preserve non-acid or weak acid fruits and vegetables are by preserving them in a pressure cooker with 10 to 15 lb. pressure ; salting them down ; drying or dehydration ; pickling ; deep freezing."

(Bulletin No. 43, referred to earlier.)

MEN AND SCIENCE

It is not suggested that Men and Science be taken as a separate topic. Occasions will arise where work of the great discoverers and inventors will fit naturally into the investigations being undertaken. The teacher can play an active part here ; he can introduce names at the appropriate time. For example, an obvious time to introduce the work of Pasteur would be when children are investigating the souring of milk.

Teachers will probably find it best to allow small groups of individuals that have shown interest and ability in this work to communicate the results of their researches in the ways that have been used for other topics.

A vividly related anecdote of a famous scientist's or inventor's life can give children a historical perspective of science and an insight into its creative aspects.

An activity that teachers might like to encourage is the dramatization of scientists' lives, involving the actual experiments that made them famous—for example, Galileo's experiments with inclined planes.

In one school children decided to write and perform a play on the life of Galileo. The teacher believed that this was an excellent opportunity for integrating science, history, art, written expression, and dramatization. Little direction was given by the teacher in order to encourage the children's initiative and independence. In the teacher's words, " With the emphasis upon complete participation, every member of the group was an actor/actress and a scriptwriter/adviser. The children chose the incidents that they portrayed, and conducted research and collated material themselves." Here are some extracts from one of the plays. Only the spelling has been altered.

(A)

ACT I

Narrator : This is a story when two lenses were held about a foot apart. This is what happens. The scene is in a Dutch spectacle-maker's shop.

Spectacle-maker : What is this ? I've never done anything like it in my life. I wonder how I did it ! The church has come nearer to me.

Narrator : Some scientists hear about it and come.

Scientist 1 : Give me a look.

Scientist 2 : I want a look, too.

Spectacle-maker : You can't both see through it at the same time.

Narrator : They all have a look.

Scientist 1 : Amazing !

Scientist 2 : Astounding !

Spectacle-maker : What can we call it ? I know. The " Scope ".

Scientists : That's a good idea.

(B)

ACT II

NARRATOR : An eavesdropper had overheard all this and was on his way to Galileo. He goes to Galileo's study.

EAVESDROPPER : Galileo ! I overheard a conversation about a scope.

GALILEO : What is a scope?

EAVESDROPPER : It works like this. There are two lenses held about a foot apart. One is held to the eye and the other a foot away. Then you look through the scope. It makes things that are far away come closer.

GALILEO : That is very interesting. I will make one.

NARRATOR : Galileo made a scope and became so interested in it he finally made a telescope.

NARRATOR : Two years later Galileo is studying the stars.

GALILEO Hey ! What are those colourful blobs circling around that planet ! I wonder how they formed ! I wonder !

* * * * *

NARRATOR : Three months later.

GALILEO : These must be satellites of another planet.

NARRATOR : Galileo did a lot more with his telescope. He drew a map of the universe, how he thought it was, and discovered more stars. He found mountains on the moon and observed the moon-like phases of Venus.

* * * * *

The scientific facts in these extracts are not great in number. The historical accuracy may be questioned too. But interest level was high at all times, far more reading and research were done than was apparent from the play, and children were made more aware of the human, social side of science.

After the play was performed a discussion was held and children were asked to write comments on their work. Here are some of them :

> " I liked making the play because it was interesting finding out the facts and putting it together."
>
> " The most enjoyable part was the rehearsals and watching the other actors. It was interesting when the actors made mistakes and tried to overcome them."
>
> " What I found out about Galileo was—
>
> (1) That he found that the pendulum would swing at the same speed from further and closer points.

(2) That he helped to prove that the earth was not the centre of the universe.

(3) That he proved that gravity attracts things at the same speed."

" We could make our next play better by practising more, by really thinking about our play, and by speaking in voices which match what kind of person we are."

Some teachers of senior grades might like to approach this unit through history, to show how man has come to understand and adapt his environment from earliest times, or to show how pure and applied science may be related. Plenty of scope for individual and group interests is possible in topics that might arise in either science or social studies. Topics such as the following would be suitable :

The beginnings of science.
The age of discovery.
How farming began.
Myths.
Industrial revolution.
Clocks.
The story of flight.
The use of metals.
The wheel.
Witchcraft.
The history of medicine.
Alchemy.
Astrology and astronomy.

Examples of topics where the lives of scientists may be treated follow. Some related topics are also suggested.

Volta, Galvani, Faraday, Franklin	Batteries, bulbs, and wires. Electricity. Static electricity. Making objects move. Happenings at a distance. Experience with light. Related topics : Power. Sending messages. Music.
Newton	Galileo—the solar system and beyond. Experiences with light (telescope).
Darwin, Linnaeus	Would be appropriate in " Life " section generally.
Fleming	Life stories. Related topic : Immunization.
Harvey	The heart. Life stories.

Morton, Simpson	Life stories. Related topic : Anaesthetics
Van Leeuwenhoek, Hooke	Light (microscope). Life stories. Collecting and caring.
Lister, Nightingale	Life stories. Related topics : Nursing. Surgery, etc.
Priestley	Household chemicals and change. Fire. Related topic : Soft drinks.
Murdoch	Making coal-gas. Related topic : Industrial revolution.
Davy	Making coal-gas. Related topics : Industrial revolution. Safety.
Röntgen, the Curies	Happenings at a distance. Related topics : X-rays. Radio-activity. Atomic energy.
Newcomen, Watt, Stephenson	Moving. Making objects move. Related topics : Industrial revolution. Railways. Coal and Iron.
Rumford	Heating and cooling. Water in food.
Galileo	Galileo—the solar system and beyond. Making objects move. Light (telescope).
Hippocrates	Life stories. Related topic : Ancient Greece.
Copernicus	Galileo—the solar system and beyond.
Jenner, Ross, Reed, Salk	Life stories.
Columbus	Magnets. Related topics : The New World. Exploration.

Goodyear	Hardness, brittleness, and elasticity. Related topic : The motor-car.
Edison	Batteries, bulbs, and wires. Electricity. Working with sound. Experiences with light. Related topics : Music. Motion pictures.
Pasteur	The souring of milk. Making bread, cheese, ginger beer. Light (microscope). Life stories. Related topic : Dairying.
Archimedes	Making work easier. Making objects move. Hardness, brittleness, and elasticity. Related topics : Tools Ancient Greece. Weapons.
Captain Cook, Lind	Life stories (scurvy). Related topics : Vitamins. Exploration. Water in food.
Hargreaves, Kay, Arkwright, etc.	Threads and fibres. Related topics : Wool, cotton, etc. (in social studies). Industrial revolution.

Lists of books containing information on these men and women will appear from time to time in the *Education Gazette* and in other Departmental publications.

A. C. Brooks, Government Printer, Melbourne.